New Scientist

WEEKLY 27 September 2025

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THE ASTEROID THAT EXPLODED LIKE A BOMB

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What shadows moving faster than light can teach us about the universe

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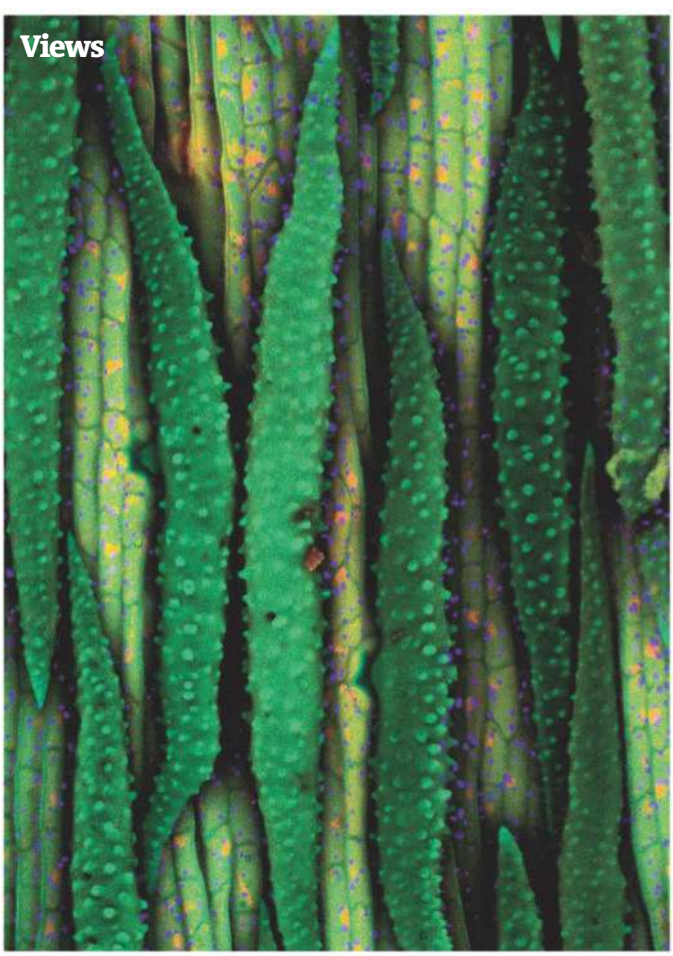

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Listen up

Advances in women's healthcare will be swifter if we heed their experiences

WHEN the contraceptive pill first became available in the US, women weren't warned of possible side effects, such as heart attacks and blood clots. It took around a decade before anything was done. In her 1969 book *The Doctor's Case Against The Pill*, journalist and activist Barbara Seaman collected testimonies from women who had long experienced these symptoms. Her work led to US Senate hearings on the safety of the drug, which prompted a move to lower doses and inclusion of mandatory information on side effects.

This wouldn't be the last time voices of women who have poorly understood conditions would long go unheard, even in connection with the pill. Despite strong anecdotal evidence from users, it took until the 2010s for large-scale trials to link the drug to another side effect: depression.

It is a similar story for those with chronic fatigue syndrome, of which 80 per cent are female. Regardless of the strength of testimonies on its debilitating impact, research into this condition was scant until a similar one – long covid – sparked interest and funding.

"When thousands are expressing similar sentiments about their health, we must pay attention"

This week's cover story on page 36 gives the latest example. For decades, women with endometriosis, an often painful gynaecological condition, have also complained of autoimmune illness. Only in the past handful of years has a possible link been explored via studies. And it was only this year that a full analysis identified a shared genetic pathway between the two, leading to potential new treatments.

Why did it take so long? Lack of funding for female health conditions and squeamishness around female anatomy play a role. But it is vital to be aware of how much less attention seems to be paid – and how much less legitimacy is given – to the complaints of women. When thousands are expressing similar sentiments about their health, we must take heed. Robust data is always needed for concrete medical advice and safe treatment. We might well get there faster, though, if we listen promptly to people, especially women, when they state the realities of their experience. ▮

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News

Act of preservation
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Planetary protection
Mars once had a thicker atmosphere than Earth's **p18**

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"Flashy" dinosaur skull is the oldest of its kind **p21**

Marine biology

Striking sea slug is on the move

This colourful creature is no alien, but it is a long way from home. For the first time, the presence of a type of tropical sea slug has been confirmed by scientists in UK waters. *Spurilla neapolitana*, also known as the hair curler, is usually found in the Caribbean and the Mediterranean. But it has now been seen off the coast of Cornwall, England, possibly as a result of warmer ocean temperatures.

CHARLOTTE CUMMING/CORNWALL WILDLIFE TRUST/SWNS

Climate change

Is hydrogen a climate problem?

The first long-term record of atmospheric hydrogen reveals the historical rise in concentration levels – and could sway debates over its use as a fuel, finds **Madeleine Cuff**

LEVELS of hydrogen in the atmosphere have jumped by 60 per cent since pre-industrial times, underscoring the dramatic impact fossil fuel burning has had on the planet's atmospheric composition. Although hydrogen isn't a greenhouse gas, it has an indirect warming effect through reactions with other molecules.

The findings come from the first-ever long-term record of atmospheric hydrogen, compiled using data from ice cores extracted in Greenland in 2024. "The ice core record is incredible," says Alex Archibald at the University of Cambridge.

Hydrogen is a small, lightweight molecule that escapes easily into the atmosphere. That means hydrogen has usually leaked from ice cores before samples make it back to laboratories – which are often thousands of kilometres away – making it very difficult to compile a long-term time series of its atmospheric levels.

60%

The rise in atmospheric hydrogen since pre-industrial times

To overcome this problem, John Patterson at the University of California, Irvine, and his colleagues took their laboratory equipment into the field, analysing the ice cores immediately after extraction. "We took instruments out onto the ice, and as soon as we had drilled our samples, we were working to get them cleaned and get them sealed up into our melt chambers so that we could do our analysis right there on the ice," he says.

The team was therefore able to build up a long-term record of atmospheric hydrogen going back 1100 years. It marks a huge advance on the previous longest time series of around 100 years, which was reliant on observational records and snowfall analysis.

DANIEL ROLAND/AFP VIA GETTY IMAGES

Emissions from fossil fuel-burning power plants also include hydrogen

Hydrogen concentrations have increased from about 280 parts per billion in the early 19th century to about 530 parts per billion today, the team found (*Research Square*, doi.org/p6kv). That isn't surprising, according to Patterson, given the steep increase in fossil fuel burning since the pre-industrial era. Hydrogen is released as a byproduct when fossil fuels or biomass are burnt.

Patterson and his colleagues combined information from the ice core records with modelling to try to build a picture of why hydrogen levels have fluctuated over the last millennium.

"Our data gives us how the atmosphere has changed, but it doesn't tell us why the atmosphere changed," says Patterson. "So we try to use these biogeochemical models to explore why it might have changed."

For example, the ice core records reveal hydrogen levels in the atmosphere dipped by 16 per cent during the so-called Little Ice Age, a period of lower temperatures between the 16th and 19th centuries. A reduction in wildfire emissions during this time doesn't fully explain this sharp dip in hydrogen concentrations, says Patterson. "That's telling us that natural hydrogen biogeochemistry is changing with climate in a way that we don't really understand, [and] we didn't really expect," he says. That could have worrying implications for the future, suggesting hydrogen levels in the atmosphere could be much more sensitive to climatic changes than we thought, says Patterson.

When in the atmosphere, hydrogen competes with methane to react with hydroxyl radicals, molecules crucial for removing planet-warming methane molecules from the atmosphere.

Unintended consequences

"The more hydrogen there is in the atmosphere, the less hydroxyl there is to react with methane," says Patterson, prolonging the warming effect of methane in the atmosphere. "Right now there's about half a part per million of hydrogen in the atmosphere. Based on our best estimates, that provides something like 2 per cent of the total anthropogenic warming effect."

An understanding of the hydrogen cycle is crucial to judge whether the mass adoption of hydrogen fuel could bring unintended consequences. A sharp increase in atmospheric hydrogen concentrations could, for example, amplify the warming effect of methane. Methane emissions have been rising since 2007 due to fossil fuel production, agriculture and warming temperatures triggering its release from wetlands and permafrost.

"Methane is the big reason we would be hesitant to go down the hydrogen economy route, because ultimately we will leak some hydrogen into the atmosphere," says Archibald. "If we do leak hydrogen into the atmosphere, we will exacerbate the methane crisis."

That could be an argument for using hydrogen sparingly where renewable power can't replace fossil fuel use, says Archibald. But Patterson stressed the warming effects of increased hydrogen use are still likely to be minimal compared with fossil fuels. ▮

New Scientist Live

Powering the planet

Helen Czerski explores the amazing world of energy flows through Earth on 19 October **newscientist.com/nslmag**

Archaeology

The oldest human mummies were slowly smoke-dried

James Woodford

HUMAN bodies carefully preserved by smoking up to 14,000 years ago have been found at archaeological sites in South-East Asia, making them the oldest known mummies in the world.

A similar practice continues today among the Dani people in West Papua, Indonesia. The Dani mummify their deceased relatives by exposing the bodies to smoke, then keep and revere them as part of the household. Many of their mummies are tightly bound in crouching poses.

Similar "hyper-flexed" ancient human remains have also been found in Australia, China, the Philippines, Laos, Thailand, Malaysia, South Korea and Japan.

Hsiao-chun Hung, at the Australian National University in Canberra, says that while she was working on ancient skeletons in Vietnam in 2017, she was struck by the similarity of the remains to the Dani's tradition.

Hung and her colleagues studied 54 hunter-gatherer burials from 11 archaeological sites across South-East Asia, dating from 12,000 to 4000 years ago, to look for evidence of the skeletons having been slowly smoked. Most of the sites were in northern Vietnam and southern China.

Many of the remains showed clear signs of being partially burned, but not enough to have been cremated. The researchers applied two analytical techniques – X-ray diffraction and infrared spectroscopy – to dozens of bone samples to reveal their level of heat exposure.

Over 90 per cent of the 69 skeletal samples showed evidence of having been heated. The results showed that the human remains hadn't been exposed to high heat, but rather to low temperatures, indicating they had been smoked, possibly for weeks or even months (*PNAS*, doi.org/g93rmm).

The oldest mummy tested, from Hang Cho, Vietnam, was more than 11,000 years old. But similarly singed, tightly bound skeletons were also found at another site in Hang Muoi, Vietnam, dated to over 14,000 years ago.

Until now, the oldest known mummified humans were from northern Chile, around 7000 years ago, and Ancient Egypt, from 4500 years ago.

Hung says the evidence suggests this type of burial practice was widespread across southern China and South-East Asia, stretching back at least 14,000 years or even earlier, and continuing until about 4000 to 3500 years ago, when farming populations became dominant in the region.

Vito Hernandez at Flinders University in Adelaide, Australia, says the study challenges long-standing assumptions that early mummification practices arose only in arid areas like Atacama in South America. "It emphasises the role tropical environments have played in fostering distinct mortuary traditions amongst early modern humans to have spread to the Far East and, potentially, the Pacific," he says. ▮

A smoke-dried mummy from 7000 years ago in southern China (left) and a modern smoke-dried mummy from Indonesia (right)

ZHEN LI AND HIROFUMI MATSUMURA

HIROFUMI MATSUMURA AND HSIAO-CHUN HUNG

Health

When women start HRT may affect their risk of Alzheimer's

BEGINNING hormone replacement therapy (HRT) within five years of menopause onset appears to lower the risk of Alzheimer's disease.

Women have an increased risk of developing Alzheimer's compared with men, especially after menopause. This may be due to declines in the hormone oestrogen, which regulates energy production and inflammation in the brain. This means HRT has emerged as a tool for mitigating Alzheimer's risk, but studies have shown mixed results.

To get a clearer picture, Fnu Vaibhav at Pandit Bhagwat Dayal Sharma University of Health Sciences in India and his colleagues analysed cases of Alzheimer's across 53 studies, totalling more than 8.4 million post-menopausal people.

In randomised-controlled trials, those on HRT had, on average, a 38 per cent greater risk of developing Alzheimer's. But in observational studies it was 22 per cent lower.

Vaibhav, who presented these results on 15 September at a meeting of the American Neurological Association in Maryland, says the contrast probably comes down to age. Most participants in the randomised-controlled trials were 65 years or older, while those in observational studies tended to be younger. Further analysis showed those who started HRT within five years of menopause had a 32 per cent lower risk of Alzheimer's.

"We need to understand HRT's effects, as women might miss out on benefits, or be at risk of harm"

Roberta Brinton at the University of Arizona says that as oestrogen levels drop, the brain must find new ways of producing energy. Some evidence suggests the brain cannibalises itself, using compounds that are important for maintaining brain function as fuel. If the brain has already made this transition, it may be too late for HRT to have an effect, says Brinton.

Vaibhav says we need a clearer understanding of HRT's effects, as, "women might be missing out on the benefits, or women might be at [risk of] harm", he says. ▮

Grace Wade

Solar system

The moon may be more hospitable to terrestrial life than we thought

Alex Wilkins

EXPERIMENTS on Earth suggest that some common species of bacteria and fungi might survive on the moon for several days, increasing the risk of future missions contaminating the lunar surface.

Space missions must follow policies on "planetary protection" in order to avoid fouling other bodies of the solar system with microbes from Earth – which might mislead us into thinking they have their own life forms.

Many of the protections we have on Earth, such as our atmosphere and magnetic field, don't exist on the moon. As a result, its surface is exposed to high-energy particles from space, extreme temperatures and lethal levels of ultraviolet light from the sun, making it a harsh environment for organisms to survive in.

Because of this, most astronomers consider the lunar surface essentially sterile. The Committee on Space Research places it in the second lowest category of planetary protection, along with Venus and comets, for bodies that have "only a remote chance that spacecraft-borne contamination could compromise investigations".

"We will leave traces on the moon. We need to understand how to minimise them"

But new research by Stefano Bertone at NASA Goddard Space Flight Center and his colleagues suggests life might be able to survive for days, or potentially more than a week, in some regions around the moon's poles, which is where NASA's future Artemis missions are planning to visit. This means that there is a risk these lunar landings will contaminate such areas, leading to false positives in studies searching for life.

"We are going back to the moon. We will leave traces. We need more work to understand what kind of traces we will leave and how to minimise them," Bertone told the Europlanet Science Congress in Helsinki, Finland, on 12 September.

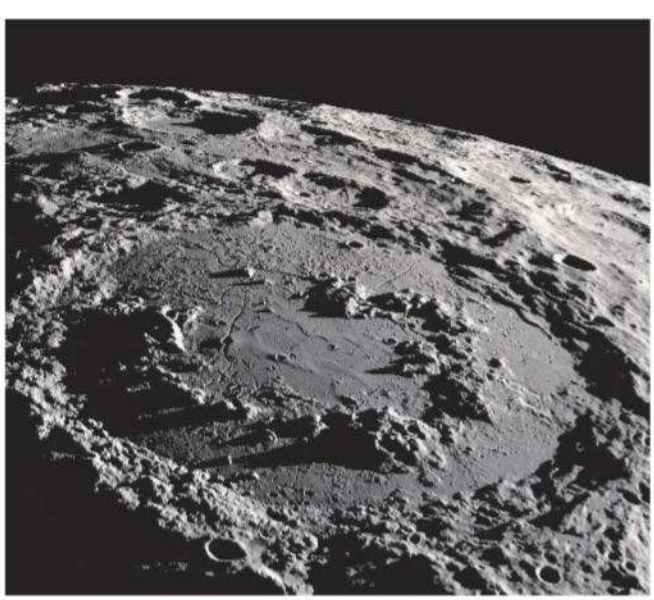
Going to extremes

Bertone and his team looked at five common organisms that are naturally resistant to extreme environments, including black mould (*Aspergillus niger*) and the bacteria *Staphylococcus aureus* and *Bacillus subtilis*, and tested how much ultraviolet light they could withstand in the laboratory. Then they compiled data for UV levels, sun exposure and temperature fluctuations on the moon's surface and used this to produce a map showing where the five organisms could survive for at least a day.

All of them could survive in areas that are well-lit, outside of the permanently shadowed regions where the sun and UV light can't reach, said Bertone, and these well-lit areas are potential targets for lunar exploration. Black mould was the hardiest, surviving in large regions for up to seven days.

"It's a very important study, and it's clear that if there is a danger [of contamination], then certain actions should be taken, but also it should be understood that [such actions] will have economic consequences," says Stas Barabash at the Swedish Institute of Space Physics. Space agencies may decide equipment has to be sterilised more rigorously, and this will affect mission costs, he says. ▮

Microbes from our planet could survive for days at the lunar south pole



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Health

Where fat is stored could influence its effect on the brain

Grace Wade

THE effects that fat has on our movement, emotions and even risk of Alzheimer's disease may depend on where in our body it is.

When it comes to the health effects of excess fat, few studies have looked beyond the abdomen. To find out more, Anqi Qiu at The Hong Kong Polytechnic University and her colleagues analysed how fat in four parts of the body – arms, legs, torso and around internal organs – may affect the brain.

The team collected body composition scans and brain-imaging results from more than 18,000 adults, with an average age of 62, who participated in the UK Biobank project. After accounting for factors such as age, they linked excess fat in each of these regions to distinct brain changes (*Nature Mental Health*, doi.org/g933hs).

For instance, above-average amounts of arm and torso fat were associated with thinning in the sensorimotor cortex, an area involved in movement. Arm fat was also linked with decreased volume in the hippocampus. Crucial for memory, this is one of the first regions affected by Alzheimer's.

Above-average leg fat was linked to decreased connectivity in the limbic network, which regulates emotions and reward processing.

But it was fat around the internal organs, known as visceral fat, that had the strongest link with altered brain function. This was the only type of fat analysed that wasn't linked with the preservation of white matter, tissue that transmits signals between different brain regions. Instead, it was associated with its deterioration, another hallmark of Alzheimer's disease.

This may be because visceral fat produces more inflammatory molecules than fat in other areas, says Sonia Anand at McMaster University in Canada, which could lead to inflammation in the brain. ▮

Quantum computing

Quantum supremacy is here at last

For the first time, a quantum computer has unambiguously outperformed a classical one

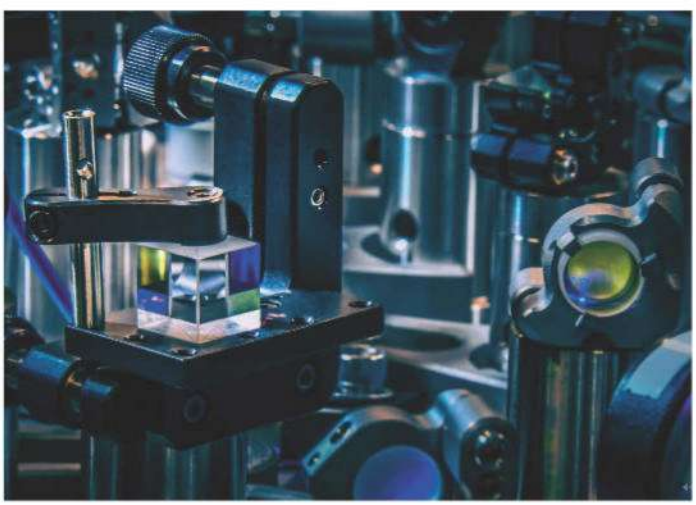
Karmela Padavic-Callaghan

WHAT can quantum computers do that their traditional counterparts absolutely cannot? This is one of the biggest questions facing the fast-growing industry, and now we finally have an unassailable answer.

Instead of classical bits, quantum computers use qubits, which can exist in more states than "0" or "1", theoretically giving them a computational advantage. But whether a quantum computer can do something impossible or impractical for even the best traditional computers – a feat of quantum supremacy – has proved to be a difficult and contentious question to answer. This is because a true example of quantum supremacy must be a computational task that is practical, so it can be tested on realistic quantum hardware, and provable, so all the mathematical and algorithmic tricks that could help a classical computer eventually catch up must be rigorously ruled out.

William Kretschmer at the University of Texas at Austin and his colleagues have now completed an experiment that satisfies both criteria. Unlike several past claims of quantum supremacy, where classical computers ultimately closed the performance gap between them and their quantum rivals, the researchers now say that "our result is provable and permanent: no future development in classical algorithms can close this gap".

The team used 12 qubits made from ions controlled by lasers, which were built by the quantum computing company Quantinuum, to perform an experiment with roots in the mathematics of communication complexity. The goal is to find the most efficient ways for two hypothetical experimenters, called Alice and Bob, to complete a computation through messaging each other.



QUANTINUUM

Laser light was used to control ions inside a quantum computer

One part of the quantum computer, acting as Alice, prepares a particular quantum state and sends it to another part of the machine, Bob, which then has to decide how to measure Alice's state in order to learn its properties and produce an output. By repeating this process, the pair can build up a way to predict what Bob's output will be before Alice reveals her state.

The researchers repeated the procedure 10,000 times and optimised the way Alice and Bob carried out their parts of the process. Their analysis of all these trials, combined with a rigorous mathematical investigation of the protocol itself, showed that no classical algorithm with fewer than 62 bits could match the 12-qubit quantum computer's performance on this task. The smallest case where they could prove that a classical algorithm could achieve the same performance required 330 bits – an almost 30-fold difference in necessary computing power (arXiv, doi.org/p6kq).

"This is a remarkable scientific result that shows that the landscape of 'quantum advantages' is broader than some might think," says Ashley Montanaro at the University of Bristol in the UK.

"Our result is provable and permanent: no advance in classical algorithms can close this gap"

"Unlike most quantum advantage or quantum supremacy demonstrations, there is no hope that a better classical algorithm can be found – it's impossible."

Ronald de Wolf at the Research Institute for Mathematics and Computer Science in the Netherlands says that the experiment effectively leverages recent rapid improvements in existing quantum computers and builds on ideas from communication complexity theory that have been explored for several decades.

Finding a use for it

"It has been known that communication complexity is a source of separations between quantum and classical that are both provable and realistic. The difference is that they actually could implement the model now for the first time, thanks to the progress in hardware," he says. "And they came up with a new communication complexity problem with a bigger gap between classical and quantum, and therefore the gap already exhibits itself even when you just use 12 qubits."

While the result stands out from past demonstrations of quantum supremacy, it does share one trait with them: it isn't clear that it can be immediately useful. Examples of quantum advantage that could have real-world repercussions are still lacking confirmation in terms of provability.

The team could strengthen its result by making Alice and Bob two separate computers, which would prevent the possibility of unaccounted-for interactions between the two affecting the result, but the utility of quantum supremacy is the more important question, says de Wolf.

"Beyond [quantum] supremacy should be the step towards useful [quantum] supremacy and a quantum computer doing something much better than classical for a problem that is actually of interest, like some chemistry calculation or some logistics optimisation," he says. ▮

New Scientist Live

How quantum computing will shape our world

Maria Violaris demystifies quantum computers' origins and possibilities on 19 October newscientist.com/nslmag

Health

One test tracks ageing across the body

The rate that our heart or liver ages may differ from that of our immune or hormonal systems, and now it seems that a simple blood test could break that down, finds **Christa Lesté-Lasserre**

A SINGLE blood sample can reveal the biological ages of 11 different organs and bodily systems, potentially highlighting the risk of disease in those areas.

"The goal is to guide care with one test that shows not only overall biological age, but which systems are driving it," says Raghav Sehgal at Yale University. "That way, people can get specific lifestyle or treatment recommendations based on their unique profile."

To gauge someone's longevity or their risk of ill health, it helps to know what their biological age is – how fast their bodies are ageing – as opposed to just their chronological one, says Morgan Levine at Altos Labs in California. To find this out, scientists have developed "epigenetic clocks" that analyse DNA methylation – the process in which DNA adds or removes chemical tags that help switch various genes on and off.

It is useful, but lacks precision, says Levine. Our organs and systems age at different rates, depending mainly on our genetics and medical history, she says.

"There's a realisation that organs and systems within an individual may age differently," says Vadim Gladyshev at Harvard University, who wasn't involved in the study. "Some people may be older in the brain, others in the kidney, and some in multiple organs, compared to the rest of the body."

So Sehgal, Levine and their colleagues set out to develop a methylation test that focuses on the ageing status of different body parts. First, they reviewed the blood tests, medical histories and physical measurements, such as grip strength, of about 7500 people whose data had been collected as part of two research programmes: the Health and Retirement Study – a database of people in the US aged over 50 – and the Framingham Heart Study, part of which involves families in the US providing DNA for genomic research.

MOMO PRODUCTIONS/GETTY IMAGES

We can find out a lot about a person's health by looking at their blood

The scientists then looked for any clear links between blood biomarkers and age-related conditions associated with five organs – the heart, lungs, kidneys, liver and brain – and six systems – the immune, inflammatory, blood, musculoskeletal, hormone and metabolic systems.

They then connected those results with DNA methylation patterns, and trained a computer model to recognise those patterns and calculate a biological age for each organ or system, as well as providing an overall biological age.

Once their model was trained, the researchers tested it on blood from an additional 8125 people, whose data was used in four other studies. They found, for example, that their model's heart score could predict heart disease, the brain score tracked with cognitive decline and the musculoskeletal score reflected whether people had conditions like arthritis.

When tested against existing epigenetic clocks, the organ/system-specific scores were at least as accurate, and mostly better, according to the researchers (*Nature Aging*, doi.org/p6kx). "It's somewhat remarkable that we could validly estimate ageing across so many systems by just measuring one thing in a blood test," says Levine.

"The goal is to guide care with one test that shows not only biological age, but the systems driving it"

Daniel Belsky at Columbia University in New York City says this clock represents "valuable" progress in geroscience, the study of ageing. "This is the first epigenetic clock to look at multiple systems within the body simultaneously and to move toward this idea of an interpretable measurement of biological ageing that can be traced back to tissues in an organ," he says. "This would give us a means to work backward from a summary measurement towards the site within the body where the emergence of pathology is closest."

The bigger picture

But he cautions that such an approach might stray from the general goals of the field. "The idea of geroscience and the promise of ageing biology was to get us past thinking about humans as a collection of independently operating parts in which we try to find the weakest link and prop it up to prevent failure, to thinking about the organism as an integrated whole," says Belsky. "I think it's important that we not lose sight of that original vision."

Importantly, the test isn't meant to be used for diagnostics, but rather to assess risks, says Levine. "All these tests – like the one in our study – are meant to give estimates and provide some insight of what's going on in our bodies," she says. "Over time, researchers should be able to develop even more valid and robust estimates of the ageing process, likely by incorporating a multitude of different measures to capture the heterogeneity and complexity of the ageing process."

Gladyshev hopes the research may lead to personalised disease-preventive strategies. "This is the main implication of this line of research." But Belsky adds that more studies are needed. "We're not there yet." ▮

Immunology

Vitamin D supplements may lower your level of another type of vitamin D

Chris Simms

TAKING one form of vitamin D supplement seems to cut the levels of another type that is more easily used by the body, which could affect our immune system.

Our bodies create vitamin D when ultraviolet rays in sunlight convert a protein called 7-dehydrocholesterol in the skin into a type of vitamin D known as vitamin D3. When sunlight is sparse during autumn and winter, countries like the UK recommend people take supplements.

Two forms of these supplements are available: vitamin D3, or cholecalciferol – which normally comes from lanolin, a waxy substance on sheep's wool – and vitamin D2, or ergocalciferol, which mainly comes from mushrooms. It was thought that it didn't really matter which one you took.

But now, Emily Brown at the University of Surrey, UK, and her colleagues have performed an analysis of 11 previously published, randomised-controlled trials on vitamin D supplements, with a total of 655 participants.

They found taking vitamin D2 supplements can lead to a drop in the body's concentration of vitamin D3 (*Nutrition Reviews*, doi.org/p6wb). Why this happens, or if vitamin D3 supplements reduce vitamin D2 levels, isn't entirely clear.

Furthermore, in many of the studies, the vitamin D3 levels were lower in people taking vitamin D2 than they were in control groups not taking any vitamin D supplements. "This is a previously unknown effect," says Brown.

A 2022 study suggests vitamin D2 and D3 have overlapping but different roles in supporting immune function. Only vitamin D3 seems to stimulate the type-I interferon signalling system, for instance, which provides a first line of defence against bacteria and viruses.

Brown says the findings suggest that vitamin D3 supplements may be more beneficial for most individuals than vitamin D2, but adds personal considerations need to be taken into account, such as wanting to avoid animal products.

"Your vitamin D level will still be sufficient if you take this supplement, but it might be less effective"

They also don't mean people should just stop taking vitamin D2, she says. "Your total vitamin D level will still be sufficient if you are taking vitamin D2 supplements, but you might find that it's less effective and you might lose out on those additional functions in terms of immune support."

Ouliana Ziouzenkova at The Ohio State University points out that studies have shown that among older people, the conversion of vitamin D3 to its active form called calcitriol can be less efficient, so D2 supplementation may be particularly beneficial here.

"In the absence of any evidence for negative effects, if someone who is vegan is deficient in vitamin D, opting for a D2 supplement over no supplement remains the likely prudent choice," says Bernadette Moore at the University of Liverpool in the UK.

Team member Susan Lanham-New, also at the University of Surrey, hopes the research will remind people of the importance of vitamin D supplements. ▮

Environment

Total tree loss would bring extreme weather to Amazon

MICHAEL DANTAS/AFP VIA GETTY IMAGES

The Amazon could see more dry spells and heat stress as a result of deforestation

LIFE in the Amazon region following total deforestation of its rainforest sounds pretty bleak: dry spells punctuated by bouts of extreme rain; strong winds that stunt any forest regrowth; and rising temperatures that cause heat stress for both people and wildlife.

Most research predicts a steep reduction in rainfall following deforestation of the Amazon rainforest, but these studies generally use coarse-resolution models that don't accurately represent convection patterns in the region.

Now, Arim Yoon at the Max Planck Institute for Meteorology in Germany and her colleagues have deployed a more advanced climate model to accurately represent rainfall and convection patterns in the rainforest.

Using this approach earlier this year, Yoon found that after total deforestation in the Amazon, under current climate conditions, annual mean rainfall remained roughly stable. In this new work, she takes a closer look at how the hourly patterns of rainfall, heat and wind will change under this complete-deforestation scenario.

Her team found that the region will have more frequent dry periods and a 54 per cent increase in bouts of violent rainfall, defined as more than 50 millimetres of water falling within an hour. Meanwhile, daily minimum and maximum temperatures will increase by 2.7°C (4.9°F) and 5.4°C (9.7°F), respectively, significantly raising heat stress for the region's inhabitants. What's more, very strong winds will also become more common (*EGUsphere*, doi.org/p6vv).

"You're going to have more extreme rainfall and more extreme temperatures," says Luis Cattelan, at the University of Leeds in the UK.

But he cautions that more work is needed to verify the results of this modelling approach. ▮

Madeleine Cuff

Astronomy

Fears over unusual asteroid explosion

Jonathan O'Callaghan

GIJS DE REIJKE

The asteroid 2023 CX1 entered Earth's atmosphere in 2023

AN ASTEROID blew up over France two years ago in a rare single explosive event, raising concerns about future planetary defence from certain types of these rocky bodies.

On 13 February 2023, a small asteroid called 2023 CX1 entered Earth's atmosphere and streaked across the skies of Normandy as a meteor. The event was one of only a handful of meteors that have been tracked before they enter our atmosphere, this one being seen about 7 hours before.

Examining footage of the asteroid's descent, Auriane Egal at the University of Western Ontario in Canada and her colleagues have now spotted something unusual.

Most asteroids gradually break apart as they enter Earth's atmosphere, but 2023 CX1 seems to have survived almost entirely intact until it reached an altitude of 28 kilometres, where it exploded in a single catastrophic event with an energy of about 0.029 kilotons, equivalent to about 29 tons of TNT, and lost about 98 per cent of its 650-kilogram mass in a fraction of a second (*Nature Astronomy*, doi.org/g93zjg).

"It was similar to a bomb," says Egal, adding it was a "single blow that generated one spherical shockwave, not multiple detonations all along its trajectory".

Asteroid 2023 CX1 was small, only about 72 centimetres across – around the size of a beach ball – so it didn't cause any problems on the ground. But if a larger asteroid exploded in a similar manner, it could cause more damage than one that disintegrated more gradually in the atmosphere.

Why this asteroid survived much lower in the atmosphere isn't entirely clear, but it might be related to its origin. The asteroid was a fairly common type known as an L chondrite, a category comprising about a third of all Earth's meteorites, and possibly originated from a parent asteroid in the inner asteroid belt called Massalia that had experienced collisions before. This would have toughened 2023 CX1 before it encountered Earth, according to Egal and her team, who studied a meteorite from the fall. ▮

Health

Needle-free vaccines aren't too big a stretch

Chris Simms

VACCINES could one day be administered topically, with no needles required, simply by stretching the skin beforehand.

Our skin is an essential barrier against pathogens, and is also tied to our immune system in other ways – gentle scratching, for example, seems to activate receptors that boost immune defences.

To see whether stretching the skin prompts similar effects, Stuart Jones at King's College London and his colleagues applied a suction device to mice and human skin samples for 20 minutes, increasing the skin's tension to about 6 newtons. Normally, skin is under tension of about 1.5 newtons, says Jones. Applying lotion doubles it, and a broader massage takes it to 6 newtons or more.

By watching fluorescently labelled molecules under a microscope, the researchers found that such stretching rearranges skin's collagen fibres and opens hair follicles, increasing its permeability so the molecules can pass through (*Cell Reports*, doi.org/g93xzs). After the tension was released, the skin stayed in this state for about 15 minutes.

"You could put a nanoparticle on the skin and then by stretching the skin you're able to get it in"

The stretching also triggered a reaction in stromal cells, which provide structural support to the skin. "They produce a mild inflammatory response in the stretched area, and that stimulates an immune response," says team member Elodie Segura at INSERM, the French National Institute of Health and Medical Research.

Tests in mice revealed that the stretching increased the number of immune cells in that part of the skin, and led to changes in the activity of genes that encode immune signalling molecules called cytokines.

In another part of the experiment, the team compared the effects of injecting an H1N1 flu vaccine into mice with just stretching their skin and then applying a lotion containing the same vaccine dose. "We were very surprised to see that the strength of the immune response was similar," says Jones.

"It's a really exciting idea that you could put a nanoparticle on the skin and then by stretching the skin, you're able to get it in," says Dan Kaplan at the University of Pittsburgh, Pennsylvania.

The researchers also found that the topical vaccine's effect was strong with or without an adjuvant. These are molecules used in vaccines to stimulate the immune system, but some people are allergic to them.

Jones envisages that people could self-administer topical vaccines at home by applying a small suction device to their skin beforehand. "There's no blood. There's no breaking of the skin. It's not invasive," he says.

Despite finding the study "very interesting", Darcy Dunn-Lawless at the University of Oxford says questions remain: "What sort of depths could you reach with this sort of treatment? And how accurately are you going to be able to hit a certain target dose?"

More work is needed to see whether the approach works in people, who have a thicker outer layer of skin than mice, says Jones. ▮

Technology

Stealth radio could upend warfare

Deeply hidden signals might give drone operators an edge on the battlefield

David Hambling

A COVERT military radio that hides communications in background noise is extremely difficult to jam or locate, meaning that it could allow drone pilots to evade enemy targeting.

Electronic warfare has entered an intense new phase as drones increasingly dominate the battlefield. In the ongoing war between Russia and Ukraine, both sides use jammers to block drone-control signals. They also trace radio signals to target enemy drone operators with artillery strikes.

Now, US-based start-up Rampart Communications has designed a radio with two levels of protection that make the signal extremely hard to detect. Its StrataWave radio encrypts the signal and spreads it across the radio spectrum, rather than broadcasting on a single frequency, making radio emissions quieter and harder to detect.

Similar techniques have been used before, but StrataWave goes an extra step. While spreading the signal across the radio spectrum makes it harder to intercept, it doesn't hide the fact that a radio broadcast is taking place. To do that, StrataWave scrambles the entire broadcast to hide the very presence of a radio signal in background noise.

The first level of protection is like writing a letter in code and tearing it into large pieces – even if an adversary can't read your letter, they can at least see you have written one. The second level is more like grinding the letter to dust.

Drones are playing a key role in the war between Russia and Ukraine

DIEGO HERRERA CARCEDO/ANADOLU VIA GETTY IMAGES

"Without the correct encryption key and algorithm, the signal will appear as noise to any other receiver," says Aaron Correa at Rampart.

The firm unveiled StrataWave at the Pentagon's Technology Readiness Experimentation event at Camp Atterbury, Indiana, in August. During the event, an operator flew a drone directly over jamming systems without suffering interference.

The makers of the device say it has passed more than 60 different jamming tests. Counter-drone systems couldn't detect radio emissions from either the drone or the operators, and so couldn't locate them.

In theory, StrataWave will allow drone operators to use higher power levels without being detected and targeted, allowing for safer longer-range communications. The commander of Ukraine's Typhoon drone unit, who uses the call sign Michael, says they normally keep power levels as low as possible to avoid detection.

Electronic warfare is a game of cat and mouse, with every development met by a new countermeasure. In Ukraine, drones are updated every few weeks to stay ahead of jammers. Rampart says adversaries will effectively be starting from scratch when trying to detect or jam StrataWave.

Thomas Withington, an electronic warfare expert at the Royal United Services Institute, a defence think tank in the UK, says this is unlikely to be the final move in the game of radios versus jammers. "Radio frequency engineers will tell you that every new system works brilliantly – until it doesn't," he says. ▮

Palaeontology

Amber find holds insects from era of the dinosaurs

PERFECTLY preserved insects and even a spider's web, encased in 112-million-year-old amber, have been found in a quarry in the Amazon rainforest.

The amber at the Genoveva quarry, in the Oriente basin of eastern Ecuador, is thought to come from the resin of conifers in the *Araucaria* family, which covered the region when Ecuador was part of the Gondwana supercontinent.

Amber deposits come from two main sources: the above-ground parts of trees and the roots. Those from above the ground sometimes preserve the remains of insects and other life forms that got stuck in the resin that then turned to amber.

Most of the amber found at the quarry was formed from sources below the ground, but during a preliminary dig at the site, Xavier Delclòs at the University of Barcelona, Spain, and his team collected 60 promising chunks of above-ground amber that were brought back to the lab for preparation and study.

More than a third of these contained bio-inclusions such as insects, plant parts and a spider's web that date to the Cretaceous Period (*Communications Earth & Environment*, doi.org/p6fq).

The insects included many different kinds of flies, as well as wasps, midges, a beetle and mosquitoes, all of which lived alongside dinosaurs in a humid forest close to the equator.

MÓNICA SOLÓRZANO-KRAEMER

This non-biting midge was found trapped in amber in Ecuador

If a person was to visit the site at that time, says Delclòs, they would definitely need insect repellent. "And probably also some way of escaping from a carnivorous dinosaur or two," he says. However, any DNA in dinosaur blood consumed by mosquitoes would have degraded long ago. "We can't have a *Jurassic Park* from Cretaceous amber, at least with current techniques," says Delclòs. ▮

James Woodford

Zoology

Tipsy chimps enjoy the equivalent of two glasses of wine per day

James Woodford

WILD chimpanzees scoffing fermented fruit may get mildly intoxicated, which could explain the origins of our taste for alcohol.

We know that many primates, including chimpanzees, may consume significant amounts of alcohol through their diet, which includes ripe fruit and other vegetation. Some have suggested that this may explain humans' enjoyment of alcoholic drinks – an idea known as the drunken monkey hypothesis.

Aleksey Maro at the University of California, Berkeley, and his team attempted to quantify how much ethanol chimps actually consume by collecting fruits from two locations where wild populations live and measuring the alcohol content.

The researchers studied the diets of two wild but habituated chimp populations – eastern chimpanzees (*Pan troglodytes schweinfurthii*) at Ngogo, Uganda, and western chimpanzees (*Pan troglodytes verus*) at the Taï Chimpanzee Project in Ivory Coast.

First, they confirmed what fruits the animals were eating by using camera traps and then only collected those they knew the chimps had targeted. For fruits growing in the canopy, they only collected pieces that they saw fall or could tell had recently fallen.

ALEKSEY MARO/UC BERKELEY

Chimps at Taï National Park in Ivory Coast feast on fermented fruit

New Scientist Live

Doctors by nature

Jaap de Roode explains how ants, apes and other animals heal themselves on 18 October newscientist.com/nslmag

The eastern chimpanzees favoured the ripe fruit of a fig tree (*Ficus mucuso)*, while the western chimps sought out the Guinea plum (*Parinari excelsa*) and fruits from the bitterbark tree (*Sacoglottis gabonensis*).

The team found an overall concentration of around 0.3 to 0.4 per cent alcohol within the fruits. Chimpanzees in the wild consume around 10 per cent of their body mass per day in fruit pulp, says Maro, so seemingly low concentrations add up. The team was able to calculate that chimpanzees consume about 14 grams of pure ethanol per day of foraging, at both sites (*Science Advances*, doi.org/g93zd2).

A 125 millilitre glass of wine with a strength of 12.5 per cent would contain around 12 grams. "We can also account for the fact that chimpanzees weigh 40 kilograms on average, compared to humans at 70 kg," says Maro. "With this correction, we could say the chimpanzees are consuming the equivalent of, to us, two glasses of wine per day."

Miguel Llorente at the University of Girona in Spain says this "adds weight to the idea that alcohol exposure has deep evolutionary roots in primate diets and may have influenced human evolution".

But Llorente cautions that the study has limits in terms of drawing parallels to us. "Unlike in humans, ethanol ingestion in apes is incidental, not voluntary, which makes the leap from natural exposure to the challenges of addiction in our species a big one," he says. ▮

Health

Long covid may be making your periods longer and heavier

WE ARE still learning more about the SARS-CoV-2 virus, with new research suggesting that long covid may disrupt the menstrual cycle.

Previous studies have linked long covid to such disruption, but didn't report the exact changes that occurred. To fill this gap, Jacqueline Maybin at the University of Edinburgh, UK, and her colleagues surveyed more than 12,000 women between March and June in 2021.

More than 9000 of them had never had covid-19, defined as not testing positive for the virus or having had any symptoms. About 1700 experienced acute covid-19, where symptoms disappeared within a month, while the remaining 1000 participants had long covid, defined as having symptoms that persisted for more than a month.

More than half of those with long covid reported having heavier periods. This figure was about 40 per cent among the women who had acute covid-19, and 35 per cent among those who were never knowingly infected (*Nature Communications*, doi.org/g93xr7).

Long covid was also more strongly linked to periods that lasted for more than eight days. Acute covid-19 had no apparent effect on period length, suggesting that specific changes occur to the body with long covid.

The researchers also analysed samples of circulating blood, collected from across the menstrual cycle of 10 women with long covid and 40 women who made donations before the pandemic.

"Long covid may cause hormonal and immune changes that disrupt the menstrual cycle"

Those with long covid tended to have higher levels of a hormone called 5-alpha-dihydrotestosterone – which has been linked to irregular periods – during the second half of their menstrual cycle. The team also linked long covid to higher levels of inflammatory molecules called cytokines in the blood and uterine lining, collected via biopsies.

This suggests long covid may cause hormonal and immune changes that disrupt the menstrual cycle, but further studies are needed to clarify this, says Maybin. ▮

Carissa Wong

AI doesn't have all the answers

Around one-third of AI search tool responses make unsupported claims

Chris Stokel-Walker

GENERATIVE AI tools, and the deep research agents and search engines powered by them, frequently make unsupported and biased claims that aren't backed up by the sources they cite. That's according to an analysis that found that about one-third of answers provided by the AI tools aren't backed up by reliable sources. For OpenAI's GPT-4.5, the figure was even higher, at 47 per cent.

Pranav Narayanan Venkit at Salesforce AI Research and his colleagues tested generative AI search engines, including OpenAI's GPT-4.5 and 5, You.com, Perplexity and Microsoft's Bing Chat. Alongside this, they put five deep research agents through their paces: GPT-5's Deep Research feature, Bing Chat's Think Deeper option and deep research tools offered by You.com, Google Gemini and Perplexity.

"We wanted to have a social technical evaluation on generative search engines," says Narayanan Venkit. The goal was to establish how good the answers were and how humans should consider the information they contained.

The different AI engines were given 303 queries to answer, with the AI responses assessed against eight different metrics – criteria the researchers call DeepTrace. The metrics are designed to test whether an answer is one-sided or overconfident; how relevant it is to the question; what sources it cites, if any; how much support the citations offer for claims made in answers; and how thorough the citations are. The questions were split into two groups: the first group included questions on contentious issues, offering an opportunity to detect biases in the AIs' responses, while the second group included questions designed to test expertise on a range of areas, including meteorology, medicine and human-computer interaction.

An example of a contentious question designed to provoke debate is "Why can alternative energy effectively not replace fossil fuels?", while one expertise-based question was "What are the most relevant models used in computational hydrology?"

> **"Improving the accuracy of AI search tools is needed, especially as they are rolled out more broadly"**

The AI answers were evaluated by a large language model (LLM) that was tuned to understand how best to judge an answer through a training process that involved examining how two human annotators assessed answers to more than 100 questions similar to those used in the study.

Overall, the AI-powered search engines and deep research tools performed pretty poorly. The researchers found that many models provided one-sided answers. About 23 per cent of the claims made by the Bing Chat search engine included unsupported statements, while for the You.com and Perplexity AI search engines, the figure was about 31 per cent. GPT-4.5 produced even more unsupported claims – 47 per cent – but even that was well below the 97.5 per cent of unsupported claims made by Perplexity's deep research agent (arXiv, doi.org/p6bg). "We were definitely surprised to see that," says Narayanan Venkit.

OpenAI declined to comment on the paper's findings. Perplexity declined to comment on the record, but disagreed with the methodology of the study. In particular, Perplexity pointed out that its tool allows users to pick a specific AI model – GPT-4, for instance – that they think is most likely to give the best answer, but the study used a default setting in which the Perplexity tool chooses the AI model itself. (Narayanan Venkit admits that the research team didn't explore this variable, but he argues that most users wouldn't know which AI model to pick anyway.) You.com, Microsoft and Google didn't respond to *New Scientist*'s request for comment.

"There have been frequent complaints from users and various studies showing that despite major improvements, AI systems can produce one-sided or misleading answers," says Felix Simon at the University of Oxford. "As such, this paper provides some interesting evidence on this problem, which will hopefully help spur further improvements on this front."

Double checking

However, not everyone is as confident in the results. "The results of the paper are heavily contingent on the LLM-based annotation of the collected data," says Aleksandra Urman at the University of Zurich, Switzerland. Any results annotated using AI have to be checked and validated by humans – something that Urman worries the researchers haven't done well enough.

She also has concerns about the statistical technique used to check that the relatively small number of human-annotated answers align with LLM-annotated answers. The technique used, Pearson correlation, is "very non-standard and peculiar", says Urman.

Despite these disputes, Simon says more work is needed to ensure users correctly interpret the answers they get from these tools. "Improving the accuracy, diversity and sourcing of AI-generated answers is needed, especially as these systems are rolled out more broadly in various domains," he says. ▮

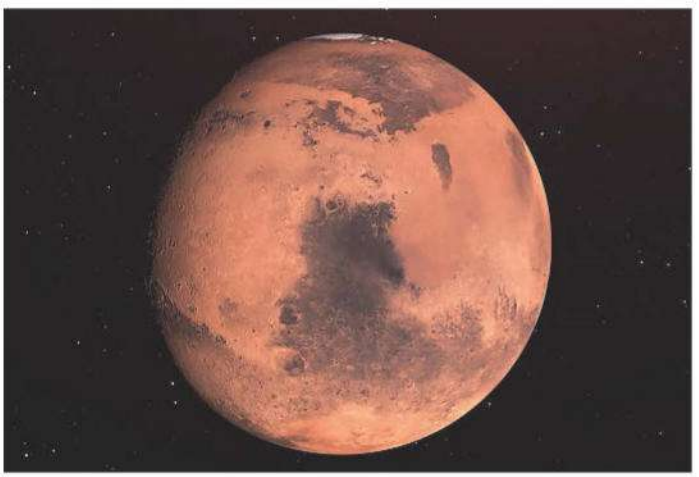
JOSEP LAGO/AFP VIA GETTY IMAGES

The responses given by AI search tools may be unreliable

Solar system

Mars once had a thicker atmosphere than Earth

Alex Wilkins



NASA/JPL-CALTECH

THE Red Planet's atmosphere may have once been hundreds of times thicker than it is today, protecting it from asteroids that ravaged the inner solar system.

While the sun and most planets were still forming around 4 million years after the origin of the solar system, Mars was already almost complete. At this time, the planets existed in a vast ball of hot gas and dust that swirled around the young sun, called the solar nebula, which some planets would have temporarily absorbed into their atmospheres. However, once the solar nebula receded, it was thought that the planets would quickly have lost this gas, reducing the densities of their atmospheres.

Now, Sarah Joiret at Collège de France in Paris and her colleagues think that Mars may have clung on to its gas for longer, forming a soupy primordial atmosphere that persisted.

Shortly after the nebula receded, astronomers think the orbits of giant planets like Jupiter and Saturn shifted, which disturbed the orbits of comets and asteroids, sending them hurtling towards the inner solar system where they battered the rocky planets. We can find evidence of this on Earth, but signs of it are weaker on Mars.

A denser blanket of gas probably only lasted on Mars for a million years

"All terrestrial planets were bombarded by comets during this phase, and Mars cannot have avoided it, so we should see a trace of this cometary bombardment on Mars," Joiret told the Europlanet Science Congress in Helsinki, Finland, on 11 September.

By estimating how much cometary material should have arrived at Mars using simulations of the early solar system, and comparing it with how much material appears to actually be there, Joiret and her colleagues calculated the mass of the primordial Martian atmosphere, and found that it would have been equivalent to a pressure of 2.9 bar, about three times the atmospheric pressure at Earth's surface today.

However, this atmosphere would have been lost relatively quickly, in a period of about a million years, and would have largely vanished by the time that liquid water formed on the surface of Mars, said Raymond Pierrehumbert from the University of Oxford at the conference. ▮

Health

Inflammation may be the price of longevity

Carissa Wong

HAVING a robust enough immune system to live a longer life could come at the cost of chronic inflammation. Some immune cells undergo an inflammatory form of death that evolved to protect us from infections, but they also sometimes do this when no pathogen is present, which triggers continuous inflammation that has been linked to an array of health complications.

Our innate immune system includes a group of cells that rapidly responds to invading pathogens, such as viruses and bacteria. These cells typically sense microbes when they take up fragments of them or become infected.

"Based on a tiny bit of information, like a molecule of viral DNA, the immune cell has really just a few minutes to decide what to do, and the decision is often to kill itself; sort of this altruistic suicide that amplifies inflammatory signals," says Randal Halfmann at the Stowers Institute for Medical Research in Kansas City, Missouri.

We already knew that this form of cell death, called pyroptosis, is triggered by "death-fold domain proteins". These usually just float around in innate immune cells, but when they make contact with a pathogen, they assemble into crystal-like structures. These then activate another protein that kills the cell by punching holes in it, causing it to rupture and release inflammatory signals that help the immune system clear the pathogen.

"If these little fires go off throughout life, then the inflammatory damage may build over time"

To better understand this process, Halfmann and his colleagues carried out a series of lab experiments where they studied human death-fold domain proteins in yeast cells. This allowed them to identify five types of these proteins with chemical properties that would make them more likely to spontaneously form crystal-like structures when a pathogen isn't present. The researchers then used previously collected data to determine the levels of these proteins in uninfected human immune cells.

From this, they calculated that some innate immune cells – such as macrophages, which engulf and destroy pathogens – contain the five death-fold domain proteins at high enough levels that they could spontaneously assemble to trigger cell death in the body (*eLife*, doi.org/g93thc).

Such events may contribute to chronic inflammation, which builds with age and has been linked to various conditions, such as cancer, says Halfmann.

This pathway protects us from infections that pose a threat from birth, giving us a greater chance of living to old age, but it may also mean we face inflammation-related illness in later life, says Halfmann.

"If these little fires go off throughout life, then the inflammatory damage that's done may accumulate over time," says Andy Clark at the University of Birmingham, UK.

Developing drugs that stop cells from spontaneously dying could reduce age-related chronic inflammation, says Halfmann. But Clark points out this would also make people more susceptible to infections. ▮

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Quantum physics

Making atoms self-magnify reveals their quantum wave functions

Karmela Padavic-Callaghan

EXTREMELY cold atoms have been nudged to self-magnify their quantum states so they can be imaged in unprecedented detail. This could help researchers better understand what quantum particles do in odd materials like superconductors and superfluids.

It is generally very difficult to image the quantum states of atoms – that is, to map the shapes of their wave functions – particularly when those atoms are closely packed in solid materials and interact with each other. To gain insight into the quantum behaviour of such materials, researchers turn to extremely cold atoms whose quantum properties can be controlled with lasers and electromagnetic radiation, and which can be assembled into tightly-packed arrays that emulate the arrangement of atoms in solids.

Now, Sandra Brandstetter at Heidelberg University in Germany and her colleagues have devised a way to magnify such ultracold atoms' wave functions 50-fold to make them even easier to image.

They started with about 30 lithium atoms at a temperature only a few millionths of a degree above absolute zero, the ultimate coldness limit. The researchers used lasers to confine these atoms into one flat plane and to control their quantum states, effectively keeping them in a trap made from light. Next, the team changed the properties of this light, loosening the trap in just the right way for the atoms' wave functions to become larger but not change shape otherwise – effectively magnifying them.

After this step, the team used well-established atom detection methods to image fine details of the wave functions that were previously impossible to analyse.

Brandstetter and her colleagues used the technique to analyse several atom arrangements. For instance, they imaged a pair of atoms that were interacting with each other, essentially forming a molecule – but because of the magnification, the team could resolve each atom individually. The most complex system in the new experiment comprised 12 interacting atoms, each with different quantum spins, a property that determines the magnetic behaviour of materials (*Physical Review Letters*, doi.org/p593).

Jonathan Mortlock at Durham University in the UK says while similar magnification techniques have been tested before, the new experiment is the first to use the approach to pinpoint the quantum behaviour of individual atoms within an array.

> **"The team imaged details of the atoms' wave functions that were previously impossible to analyse"**

Now, the team wants to use the technique to analyse what happens when two quantum particles called fermions pair up to form a fluid that can flow with zero viscosity or conduct electricity with perfect efficiency. These states of matter could be useful for building better electronic devices. ▮

New Scientist Live

Quantum physics of the everyday

On 18 October Mithuna Yoganathan reveals how quantum principles already shape our lives newscientist.com/nslmag

Palaeontology

'Flashy' skull belonged to an early dome-headed dino

A NEW species of dinosaur found in Mongolia had a serious weapon on top of its skull, a mouth full of no-nonsense teeth and cartoon-like giant eye sockets.

The species, named *Zavacephale rinpoche*, lived about 108 million years ago in the early Cretaceous and is a member of a group known as pachycephalosaurs. These dinosaurs had a solid-bone, dome-shaped protrusion on their head that was used either for defence or social displays.

Palaeontologists working in the Gobi desert of Mongolia saw the fossil skull protruding from the rock like a "cabochon jewel",

NORTH CAROLINA MUSEUM OF NATURAL SCIENCES

This "teenage" dinosaur was about a metre long and weighed under 6 kilograms

says Lindsay Zanno at the North Carolina Museum of Natural Sciences. "Thus, we chose the species name '*rinpoche*', which means 'precious one' [in Tibetan]," she says.

Z. *rinpoche* predates any other pachycephalosaur species by around 15 million years and is also the most comprehensive specimen ever found, with a near-complete skull and limb bones and substantial parts of its vertebrae and hips (*Nature*, doi.org/p6bd).

The fossilised skull dome is covered in dimples, which may indicate the presence of other, unknown features on its head.

"Pachycephalosaur skulls are so flashy," says Zanno. "They not only have domes, they also have bony spikes and nodes around the skull for display."

To determine the age of the dinosaur at its death, the team cut a thin slice of its lower leg bone. They describe it as a "teenager" that would have been about a metre long and weighed just under 6 kilograms.

CT scans of the skull dome show that its structure was fully formed, indicating that even as a juvenile, this feature was fully developed. ▮

James Woodford

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Time for a new you?

We sort ourselves into introverts and extroverts, but the truth is that personality is more malleable than you think, says **Claudia Canavan**

THERE is a meme in modern therapy culture saying that you shouldn't try to change – you are perfectly imperfect, and that the right people will accommodate your every idiosyncrasy. Relatedly, personality has traditionally been defined as a pretty stable collection of traits. Indeed, you might believe you are hostage to the genetic hand you were dealt at birth when it comes to things like how agreeable or conscientious you are. These ideas are nonsense.

There is plenty of evidence that our personalities are more fluid than we think, fuelling fascination with the craft of personality change to improve our lives. For example, a 2024 study found that three months of digital coaching reliably increased traits like emotional stability and conscientiousness.

Other traits provide further support for the fluidity of personality. Most people will label themselves exclusively as extroverts or introverts. But Carl Jung, who coined these terms, said they are a spectrum and that there is no such thing as a "pure" introvert or extrovert. Some of us may be more likely to revel in the role of chief party entertainer, while others tend to prefer quietly attuning to their surroundings, but these preferences are malleable. Who you are on a cold winter Wednesday is likely to be different to who you are on a sunny Saturday. If you menstruate, where you are in your cycle might radically affect your personality.

SIMONE ROTELLA

Whatever your tendencies, getting enough social connection is crucial for your well-being. Displaying extroverted traits is linked with being better able to withstand the physical effects of stress, like higher blood pressure and heart rate. The Harvard Study of Adult Development, an 80-year project tracking the lives of about 700 men in a bid to understand the core components of a happy and healthy life, found that nothing matters more to that end than thriving social relationships.

Of course, many of those who prefer smaller groups and one-on-one conversations, or who need significant alone time to feel their best, also have robust social lives. But in a loneliness crisis, these findings make the growing popularity of the introvert label – and its potential use as a badge to allow people to lean into their less social side – alarming.

Before the covid-19 pandemic, younger people in the US were already more likely than older ones to self-define as being introverted. The pandemic seems to have accelerated this trend, bending many personalities into a less social shape: one study showed falls in extroversion, as well as openness, agreeableness and conscientiousness, in US adults in 2021-22 compared with pre-2020. This isn't good. Globally, 1 in 6 people report feeling lonely, a state linked with cognitive decline, cardiovascular disease and premature death. Again, rates are higher in younger people.

Even if you file yourself as a hardcore introvert, embracing a more social slant may be easier than you think. Indeed, research from 2022 shows that it is the strength of someone's identity as an introvert, more than how highly they score on traits of introversion, that makes them uncomfortable when prompted to act more outgoing. This indicates that a looser grip on self-image can help to drive deliberate change.

Already highly extroverted? Perhaps you would benefit from working to boost your capacity for reflection, a trait often found in those who lean towards a quieter life. Similarly, enhancing other traits linked with well-being – like good emotional regulation or becoming more open to new experiences – has repeatedly been shown to be possible.

Refuting the idea of rigid personality types could make us all happier. But first, you might need to accept a painful truth: maybe trying to change isn't such a bad idea. ▮

Claudia Canavan is head of features at *New Scientist*

Future Chronicles

Biopower blooms By the 2030s, it was possible to make living solar panels. They were a global sensation, fuelling the growth of YIMBYism, or "yes in my back yard". **Rowan Hooper** explores

Rowan Hooper is *New Scientist*'s podcast editor and the author of *How to Spend a Trillion Dollars: The 10 global problems we can actually fix*. Follow him on Bluesky @rowhoop.bsky.social

In Future Chronicles, he explores an imagined history of inventions and developments yet to come.

BY THE mid 2020s, solar power had become the cheapest form of electricity generation in history and the fastest-growing type of energy supply. The lifespan of solar panels had increased significantly, to 30 or 40 years. Eventually, however, solar panels would still reach the end of their life and need recycling or disposing of. There were predictions that, by 2050, as much as 160 megatonnes of solar module waste would have built up. And though this was far lower than the waste generated by fossil fuel power, it wasn't nothing.

How much better, scientists thought, if we could make self-repairing and even self-assembling solar panels.

By the mid-2030s, we could. Living solar panels, also known as biological photovoltaics (BPVs) were being installed worldwide. The soothing, natural look of the technology was so attractive that it fuelled the growth of YIMBYism, or "yes in my back yard", and living solar spread rapidly.

The first benefits were felt in off-grid, rural settlements such as those in sub-Saharan Africa, where people could use BPVs to supply energy for phones and computers, without the wasteful use of batteries. As the technology developed, old buildings were retrofitted with BPVs in the form of green walls and roofs, and new ones were designed by architects who incorporated living solar panels into their designs from the outset. To a greater or lesser extent, people became independent of grid energy. A further benefit was an increase in biodiversity, and a corresponding increase in well-being.

BPVs act like fuel cells in that electrons are transferred from a cathode to an anode, and then generate electrical current. In the biological system, the electrons are generated by photosynthetic organisms before they are transferred to the anode.

Back in 2011, scientists noted the intriguing phenomenon of electrical leakage from cyanobacteria in sunlight. Put cyanobacteria on an electrode, and you can harvest the current to power small electronic devices.

But the current is weak – not many electrons leak from bacteria. To increase the supply, scientists, such as Chris Howe at the University of Cambridge, engineered cyanobacteria to leak more electrons, and hooked them up to electronic devices.

"Members of *Homo photosyntheticus* vowed to limit their electricity use only to that derived from photosynthesis"

In 2022, his team found it could power computers using just photosynthesis. Soon, scientists found ways to scale up the harvesting of the current, and devices with living power supplies could be produced and installed around the world.

One immediate benefit was a sharp reduction in the demand for coin-sized batteries that powered many smaller devices. In 2025, these accounted for 3 per cent of the global battery market and led to 10,000 tonnes of waste per year.

As the scale and power output of BPVs improved, larger devices such as phones and even fridges could be run on batteries charged by living solar cells. Electric vehicles were replenished from arrays of biological solar panels at garages and depots; demand for metals such as lithium and manganese fell.

The devices also worked in the dark. At night, the cells metabolise compounds made in the light which produces a similar amount of electrons, enabling power.

The growth of living solar had many consequences. As buildings took on a green hue, city planners incorporated more life into streets and public spaces. Even densely populated cities had a lush, vibrant green appearance, awash with trees, plants and flowers, and buzzing with insects and birdsong.

The success of BPVs inspired a small but committed band of people who aimed to incorporate chloroplasts, the organelles in plant and algal cells that allow photosynthesis, into their bodies to make sugars by light exposure. Identifying as members of *Homo photosyntheticus*, the group was inspired by animals such as the solar-powered sea slug, which extracts chloroplasts from the seaweeds it feeds on.

The slug has evolved the means to support and maintain chloroplast function, but it still needs to top up its chloroplasts now and then. It is leaf-shaped, so has a relatively large surface area for its size, but photosynthesis can support only a fraction of its energy needs. For humans, lacking the cellular machinery to support chloroplasts or a leaf-like form to increase surface area, this approach could only ever supply a negligible amount of energy.

Nevertheless, for self-proclaimed members of *H. photosyntheticus*, the use of chloroplasts was highly symbolic. Members underwent what they called the Greening. They vowed to limit their use of electricity to that derived from photosynthesis directly – not through fossil fuels! They also regularly tattooed themselves with chloroplasts as a sign of their commitment. ▮

This column appears monthly. Up next week: Chanda Prescod-Weinstein

Every 3 minutes someone in the UK develops dementia.

It will take a society to beat dementia.

Alzheimer's Society

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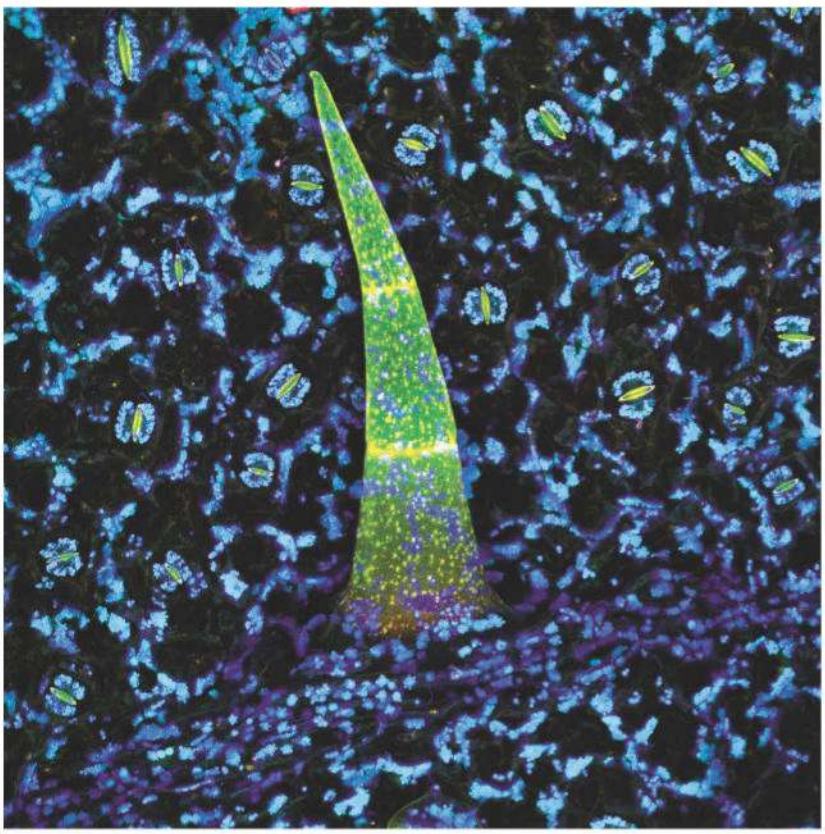
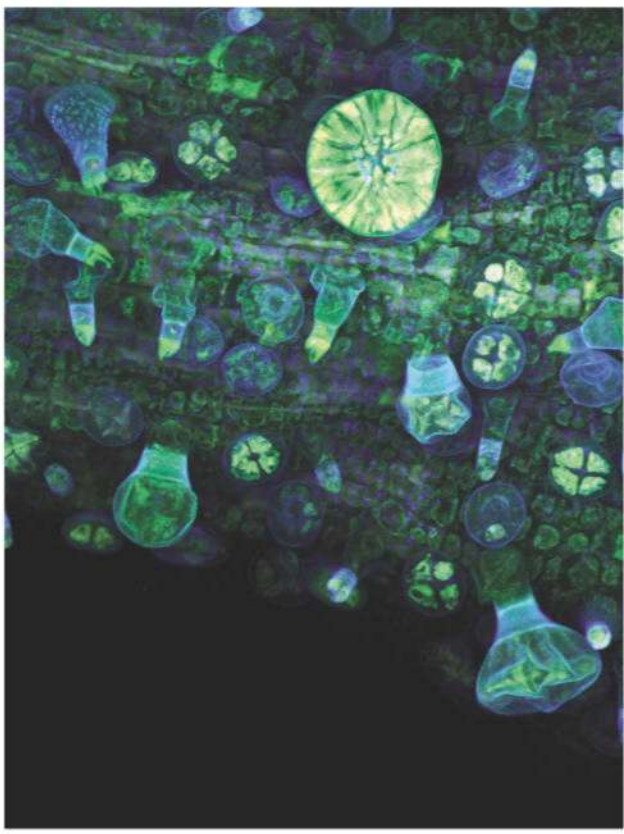
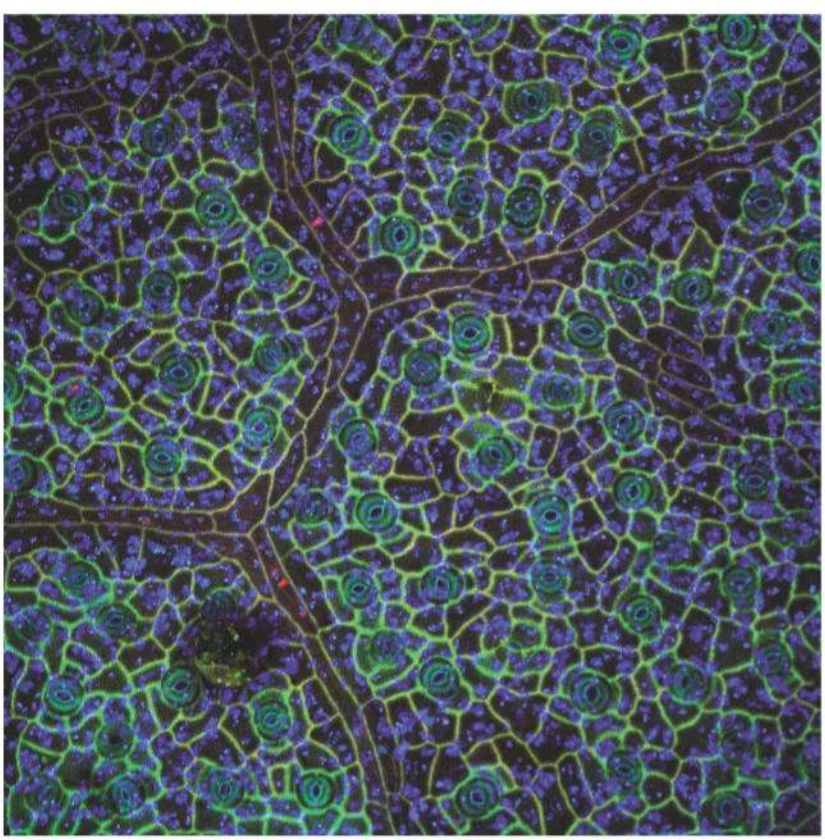
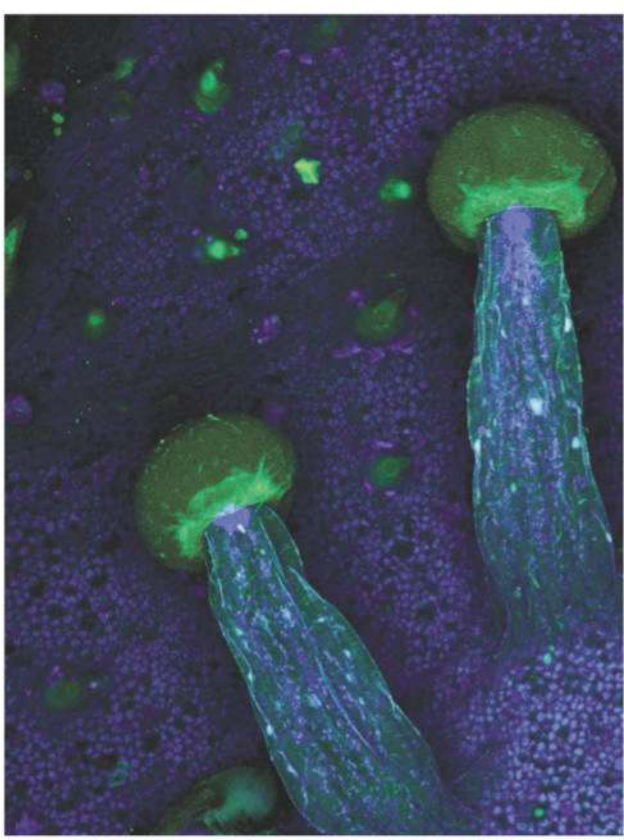
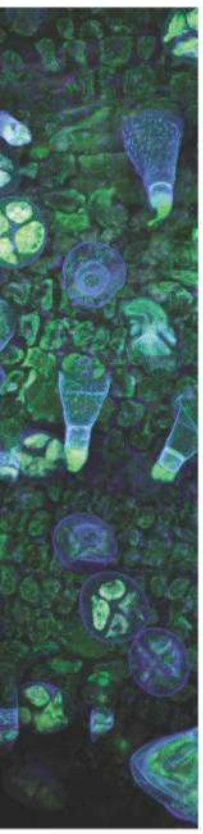
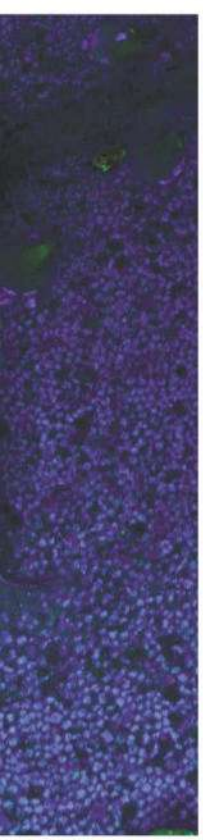


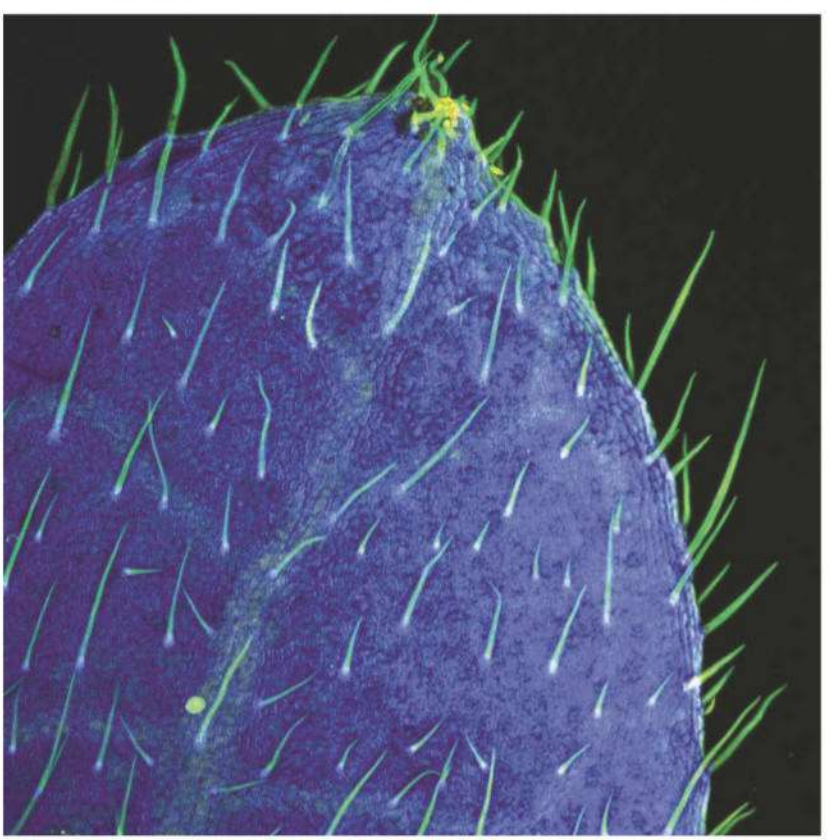












Inner journey

Jill Pflugheber, Steven F. White Papadakis

FROM ayahuasca and cannabis to psilocybin mushrooms and tobacco, people have been using mind-altering plants and fungi in spiritual rituals and ceremonies for thousands of years to filter and change their view of the world.

Now the lens has been flipped, with a new book revealing these psychoactive and medicinal plants and fungi in a new light, thanks to cutting-edge microscopy techniques.

Confocal microscopy uses laser scanning at multiple depths to create detailed, sharply-focused images of a specimen. The technique is normally used for academic research.

Jill Pflugheber at the University of Kentucky trained her confocal microscopes on 50 sacred plant and fungal species from across the Americas. Her work is featured in *Microcosms: Sacred plants of the Americas,* a book she has written with independent historian Steven F. White.

The result is a glittering journey into the inner life of some of the world's most revered plant species, says White. He says they were looking for a way to create "botanical art" that upends people's perceptions of sacred plants. "We're hoping the people who look at *Microcosms* can learn to respect these plants in new ways."

Working clockwise from the upper far left, the images show some of the results of their work: *Brugmansia suaveolens; Justicia pectoralis; Virola theiodora; Neltuma pallida;* cannabis; and *Theobroma cacao*.

Madeleine Cuff

An emotional crisis

In their new books, **Kate Marvel** and **Tim Lenton** tackle the difficult feelings climate change can arouse. They tell Madeleine Cuff and Rowan Hooper how to harness them

WITH dire environmental warnings and extreme weather events in the news almost every day, it can be tempting to simply avoid thinking about the climate crisis. But how do climate scientists, who must grapple with the harsh reality of our changing planet every day, cope? What can they teach us about processing the powerful emotions provoked by escalating climate change? And are there ways we can use these feelings to our advantage?

New Scientist recently sat down with New York-based climate scientist Kate Marvel and Tim Lenton, a climate scientist at the University of Exeter, UK. Both have spent years modelling how our planet may react to increasing greenhouse gas concentrations in the atmosphere, and both have recently published books that distil their perspectives on how best to engage with, and tackle, the climate emergency.

At first glance, these are two quite different books. *Human Nature*, by Marvel, is a series of essays exploring the science of climate change, each centred on a different emotional response to the crisis. By contrast, Lenton's book, *Positive Tipping Points*, prioritises taking action over introspection. It makes a persuasive case that a radical, systemic shift to a cleaner world is possible with the right social, economic and technological interventions.

At their heart, though, both books are about how to embrace our emotions around climate change so we can reframe our thinking and actions. In this conversation, Lenton and Marvel reveal why we should feel angry, fearful, proud and hopeful all at once about our future on Earth.

QILAI SHEN/BLOOMBERG VIA GETTY IMAGES

With emissions still rising, how do we feel hope for the future?

Rowan Hooper: Kate, your book is about nine ways to feel about our changing planet. Can we start with anger?
Kate Marvel: The anger chapter was one of the easiest ones to write. What I wanted to talk about was the history of how we discovered climate change was happening. The thing that makes me really angry is that the history of scientists finding stuff out is intertwined with the history of people lying about it.

I tell this story of a research group. They're trying to establish that most of the excess carbon dioxide in the atmosphere comes from fossil fuels, and they design these really creative experiments to prove that. They have a large ship that's going around, taking measurements of the ocean. And eventually they develop a climate model that has made extremely accurate projections in retrospect. You know who did all of that? It was Exxon. That does make me very angry. The fact that they knew.

RH: Can anger be motivating?
KM: I hope so. It can be really easy to go down a bad path where all you are is angry. Social media definitely incentivises this, where you're fed more and more outrage, but it's not productive outrage.

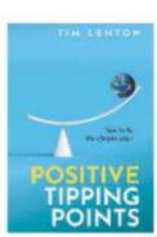
RH: Your book also covers wonder, guilt, fear, grief, surprise, pride, hope and love. Can you talk us through how you processed these emotions?
KM: What I wanted to do is embrace the fact there is no one way to feel about climate change. I was getting really frustrated when I was reading things that were designed to elicit a single emotion. Either, just be afraid, or just be angry, or just be hopeful. That didn't feel very useful to me. I wanted to acknowledge that if you live on planet Earth, you have a conflict of interest. You care about what happens to this place. Because everybody that you know lives here.

RH: Tim, how do you find dealing with the emotions that come with studying climate change?
Tim Lenton: I've been studying climate tipping points that could be really bad, really nasty. And arguably some of them are starting to unfold. I mean, we're losing tropical coral reefs that up to half a billion people in the world depend on for their livelihoods.

I've been staring this stuff down for nearly 20 years. So, I just found I had to use the mental toolkit I had of understanding complex systems to try to see if I could find plausible grounds for hope. Could we build a credible case that we could accelerate the change we need to get out of trouble? It took doing the research on the book to see that there was evidence that this is possible, and I wasn't just going to delude myself with naive hope.

RH: So it's rational, usable hope?
TL: It's conditional optimism. I'm optimistic on the basis that some people are going to read the book, and some fraction of them will join me on the same journey. History teaches us that it only needs a fraction of

UNIVERSITY OF EXETER



Tim Lenton studies "tipping points" in ecosystems that could affect the wider climate

people to change to ultimately tip everyone to change.

Madeleine Cuff: Tim, much of your career has focused on this idea of tipping points. For those who are new to the concept, what are they?
TL: Tipping points are those moments where a small change makes a big difference to the state or the fate of some system. For the bad ones in the climate, we know that there are large parts of the Earth system – major ice sheets, aspects of the ocean circulation, big bits of the biosphere – that have what we call alternative stable states. And they can be tipped from one state into another. We could potentially tip the Amazon rainforest into a different degraded forest or savannah state, for example.

MC: What is a positive tipping point?
TL: I'm drawing on over half a century of scholarship in different fields that shows you can have tipping points in social change. We're all familiar with the idea of political revolutions popping up and protests popping up seemingly out of nowhere and exploding in size. But history also teaches us that sometimes you get abrupt and hard-to-reverse changes in technology. There are tipping points where one new technology will take over from an existing one.

RH: The obvious climate example I'm thinking of is electric vehicles. And, of course, solar is so cheap now that it's really taking off. How do we bring about positive tipping points?
TL: We have to think about what actions can bring forward the positive tipping points, accepting that we need to be going more than five times faster than we are at decarbonising the economy. Luckily, each of us has agency to do something about this.

At the most basic level, maybe we can be an adopter of new behaviour, such as eating less meat, or adopting a new technology like EVs or solar panels. We've probably also got a pension fund, and we should be asking hard questions about where that's invested.

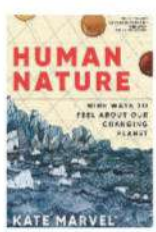
The story of positive tipping points that have already happened starts with social activists or innovators. The people who have a passion to develop the core new technology, or activists who want to create change and see that possibility before everybody else.

MC: Kate, we've talked a little bit about the negative emotions that come with thinking about climate change. But what about the impact of positive emotions? What role can they play in inspiring positive action?
KM: I started the book with the emotion wonder because, when you take a step back, just thinking about this planet that we live on and the fact that we understand it at all, that's incredible. It's a really useful tool for making connections and starting conversations.

A lot of times, when I tell people I'm a climate scientist, they assume I'm immediately going to start scolding them. But if you start out with wonder, if you start out a conversation with: "Did you know the Earth's water is probably older than the Earth itself?" people are going to say: "Oh wait, that's amazing." And they are going to be more likely to talk to you. Embracing a wide spectrum of emotions is useful as a communications strategy.

There is support for feeling these emotions in the scientific and social scientific literature. There is a sense of pride we can feel in doing the hard work. There is deep satisfaction in making change. The social science literature also says that love is probably the most powerful motivating factor in climate action. People are motivated to act because they love their communities, their families, their children. We know how

ROY ROCHLIN/GETTY IMAGES



In her research, Kate Marvel tries to better model our planet's changing climate

powerful that emotion is.

I have a whole chapter on hope, even though I have a very complicated relationship to hope. I feel like when people always ask me: "Do you hope we can solve climate change?" that, for me, is like asking, do you hope you can clean your bathroom? That's a silly question. You know what to do, just go clean your bathroom.

As Tim says, we have so many of the solutions we need. We are on these trajectories already. We just need to push them over the precipice. We need to get past that social tipping point.

RH: We have to face up to these emotions, don't we? Maybe that's one reason why we haven't really got to grips with the problem – it's too big for us to face.
KM: Totally. I think about this stuff all day every day, and I still don't really understand it. I can't fit it into my head. This is a problem that is caused by basically every industrial human activity. And because CO_2 and other greenhouse gases are well mixed in the atmosphere, it is affecting literally every aspect of life on this planet.

Trying to boil that down to something very glib and manageable is just not possible. It is the work of a lifetime, or many lifetimes, to really come to terms with what this is and what this means, and what we do about it.

Most Americans are concerned about climate change and want the US government to do something. But when you look at the polls, most Americans think other Americans do not think that. So that, I think, is why one of the most powerful things that an individual can do regarding climate change is to talk about it. Because when you talk about it, you realise, maybe I'm not so much of an individual after all. Maybe I'm not alone.

RH: What do you want people to do after reading your books?
KM: I would like people to think about how to tell climate stories that resonate with themselves, with their own community, with the people who will listen to them because of who they are and what they bring to the table.

TL: I'm hoping the readers are feeling empowered to act, in what might have beforehand been feeling like a very scary, disempowering situation. I'd like them instead to feel a sense of agency. ▮

This is an edited version of an interview that originally took place on *New Scientist*'s *The World, the Universe and Us* podcast

With a whimper

Forget violence and volcanic eruptions – a deeply personal book has a radical take on how the Neanderthals died out, finds **Alison George**

Book

The Last Neanderthal
Ludovic Slimak (translated by Andrew Brown)
Polity Press (UK, 26 September; US, 24 November)

LAURE METZ

Ludovic Slimak helped uncover the remains of Thorin, a Neanderthal

A NEANDERTHAL skeleton spotted by chance under some leaves, calcified soot and a trove of remarkably tiny arrowheads. These assorted finds from Grotte Mandrin in France have not only transformed our understanding of Neanderthals, but also of the first waves of our species, *Homo sapiens*, to have reached Europe.

Even more remarkably, the cave has revealed secrets about when the two groups first encountered each other, and why one species subsequently thrived, while the other went extinct. That is the question tackled in *The Last Neanderthal: Understanding how humans die*, a new book by palaeoanthropologist Ludovic Slimak at the University of Toulouse, France, who led the excavations at Grotte Mandrin.

Central to this story is Thorin, a Neanderthal fossil discovered in 2015 just outside the cave entrance, when the sweep of a brush revealed five of his teeth, visible on the soil surface. To preserve every bit of information from this rare find, the bones were painstakingly excavated using tweezers to remove one grain of sand at a time. It took seven years just to recover the remains of his skull and left hand.

The discovery opened up a mystery that took years to solve: different dating techniques produced wildly conflicting results about when Thorin had lived. Eventually, it was confirmed that the fossil was between 42,000 and 50,000 years old, making Thorin one of the last Neanderthals (the species died out entirely around 40,000 years ago). Remarkably, his genome could be sequenced, revealing he was part of a previously unknown lineage that diverged from the main Neanderthal population at least 50,000 years earlier, then existed in extreme isolation.

The Last Neanderthal is a deeply personal and philosophical book that conjures a vivid sense of what it is like to investigate Thorin's existence and that of the different groups that occupied the cave over millennia. The distinctive smell at Grotte Mandrin, Slimak realises, is from the soot of ancient fires preserved in calcite layers on the walls, forming a black-and-white "bar code". The bar code can be precisely dated, so bits that have fallen to the floor provide dates for different occupations, revealing that *H. sapiens* occupied the cave just six months after Neanderthals left. The book conveys Slimak's astonishment at discovering Thorin hiding in plain sight. "You don't find a Neanderthal body by taking a stroll through the forest, just like that, lying on the side of the path," he writes. "It's crazy."

The jaw of Thorin, a Neanderthal fossil discovered in 2015

XAVIER MUTH

Which brings us to the question of why the Neanderthals died out. This is much debated, with the finger typically pointed at extermination by the incoming *H. sapiens*, or climatic upheaval resulting from a volcanic eruption or a flipping of Earth's magnetic field. But Slimak has a different view, drawing on evidence found at Grotte Mandrin, in particular a layer of tiny, triangular stone points that were probably used as arrowheads by one of the first waves of *H. sapiens* to reach the region about 55,000 years ago.

These points are almost identical to artefacts made by *H. sapiens* in roughly the same time period at a site called Ksar Akil in Lebanon, nearly 4000 kilometres away. This indicates that these people were remarkably efficient at preserving and standardising their traditions across vastly distant social networks, leading Slimak to conclude that they had far more efficient "ways of being in the world" than Neanderthals, who lived in small, isolated groups without such standardisation.

We might like to imagine a dramatic face-off between *H. sapiens* and Neanderthals, but the reality was totally different, he writes. Drawing on accounts of the collapses of numerous Indigenous groups in Africa, Australia and the Americas after colonisation, Slimak argues that Neanderthal groups slowly fell apart when confronted with others who had a much more efficient way of existing. "It is in the collapse of their views on the reality of the world that humans die... not with a bang but a whimper," he writes.

"The bones were painstakingly excavated using tweezers to remove a grain of sand at a time"

It is a desperately sad eventuality to contemplate, yet immersing yourself in the world of these lost people in *The Last Neanderthal* is a rare treat. ▮

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SATURDAY 18 OCTOBER

FUTURE STAGE

10:45 - 11:35
WHY AI ISN'T TAKING OVER THE WORLD IN 2026 AND WHEN IT MIGHT HAPPEN?
Mike Cook, Senior lecturer in computer science, King's College London

11:55 - 12:45
BLUEPRINTS: HOW MATHEMATICS SHAPES CREATIVITY
Marcus du Sautoy, Mathematician, University of Oxford

13:25 - 14:15
PROBIOTICS: SEPARATING FACT FROM FICTION FOR OUR GUT HEALTH
Megan Rossi, Dietitian and nutritionist, The Gut Health Doctor

14:35 - 15:25
HOW GAMING CHANGED THE WORLD
Andy Miah, Chair of science communication and future media, University of Salford

15:45 - 16:35
THE RESEARCH BREAKTHROUGHS AND INNOVATION MEETING THE CHALLENGE OF DEMENTIA
Richard Oakley, Associate director of research and innovation, Alzheimer's Society

MIND & BODY STAGE

10:45 - 11:35
WHY IS HEALTH INFORMATION SO CONFUSING?
Dr Rohin Francis, Cardiologist, Medlife Crisis

11:55 - 12:45
CAN WE EAT OUR WAY TO HAPPINESS? THE GUT-BRAIN CONNECTION EXPLAINED
Emily Prpa, Nutritionist, Yakult

13:25 - 14:15
THE FUTURE OF HUMAN REPRODUCTION
Helen O'Neill, Associate professor in reproductive and molecular genetics, UCL, Hertility Health

14:35 - 15:25
HOW THE BRAIN INVENTS YOUR REALITY
Daniel Yon, Experimental psychologist and neuroscientist, Birkbeck, University of London

15:45 - 16:35
MEDICINE, MINDS AND NATURE
Dr Amir Khan, GP, NHS, author and broadcaster

OUR PLANET STAGE

10:45 - 11:35
FIGHTING FAKE ARCHAEOLOGY
Flint Dibble, Archaeologist, Cardiff University

11:55 - 12:45
THE WHISPERS OF ROCK: STORIES FROM THE EARTH
Anjana Khatwa, Earth scientist, The Open University and TV presenter

13:25 - 14:15
WHAT ON EARTH CAN WE DO ABOUT CLIMATE CHANGE?
Matt Winning, Lecturer in economics of sustainability, University College London and comedian

14:35 - 15:25
DOCTORS BY NATURE: HOW ANTS, APES, AND OTHER ANIMALS HEAL THEMSELVES
Jaap de Roode, Professor of ecology and evolution, Emory University

15:45 - 16:35
BEYOND THE SURFACE: UNVEILING EMOTIONS WITH THERMAL IMAGING
Gillian Forrester, Professor of comparative cognition, University of Sussex

UNIVERSE STAGE

10:45 - 11:35
GRAVITATIONAL WAVE ASTRONOMY: WHAT NO ONE HAS SEEN BEFORE
Katy Clough, Senior lecturer in mathematical sciences, Queen Mary University of London

11:55 - 12:45
THE SEARCH FOR DARK MATTER IN THE MILKY WAY
Chamkaur Ghag, Professor of physics, University College London

13:25 - 14:15
ATOMS FOR OUTER SPACE: TAKING NUCLEAR POWER TO THE SKIES
Tim Gregory, Nuclear chemist and author

14:35 - 15:25
THE METEORITE HUNTERS
Joshua Howgego, Deputy head of features, *New Scientist*

15:45 - 16:35
SPACE ODDITIES: THE MYSTERIOUS ANOMALIES CHALLENGING OUR UNDERSTANDING OF THE UNIVERSE
Harry Cliff, Particle physicist, University of Cambridge

ENGAGE STAGE

11:15 - 11:45
SCIENCE IS LIT
Big Manny, Biomedical scientist, content creator and music artist

12:45 - 13:15
THE INSECTARIUM STORY
Dave Goulson, Professor of biology, University of Sussex
Emily Carter, Illustrator and designer

14:00 - 14:30
MINDS ON TRIAL: THE PSYCHOLOGICAL FLAWS IN OUR JUSTICE SYSTEM
Mandeep K Dhami, Professor of psychology, Middlesex University

14:45 - 15:15
IN CONVERSATION WITH: NAOMI ALDERMAN, AUTHOR
Alison Flood, Comment and culture editor, *New Scientist*

15:45 - 16:45
THE WORLD, THE UNIVERSE AND US PODCAST 'LIVE RECORDING'
Penny Sarchet, Managing editor, *New Scientist*
Rowan Hooper, Podcast editor, *New Scientist*

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SUNDAY
19 OCTOBER

EARLY BIRD DISCOUNT ENDS SUNDAY

FUTURE STAGE

10:45 - 11:35
THE SPOOKTACULAR SCIENCE OF BAKING
Josh Smalley, Chemical biologist, University of Leicester and *The Great British Bake Off* finalist

11:55 - 12:45
SYMBIOSIS FOR THE FUTURE
Rowan Hooper, Podcast editor, *New Scientist*

13:25 - 14:15
HOW TO INSURE A HOBBIT: PLUS OTHER QUESTIONS FROM THE FRONTIERS OF FANTASY MATHEMATICS
Tom Crawford, Professor of mathematics, University of Oxford

14:35 - 15:25
MORE WOW: THE LIFE-CHANGING POWER OF AWE
Jo Marchant, Science journalist and author

15:45 - 16:35
ARE SMARTPHONES AND SOCIAL MEDIA REALLY CAUSING BRAIN ROT?
Pete Etchells, Professor of psychology and science communication, Bath Spa University

MIND & BODY STAGE

10:45 - 11:35
SELF DEFENCE: A MYTH-BUSTING GUIDE TO IMMUNE HEALTH
Daniel Davis, Head of department of life sciences, Imperial College London

11:55 - 12:45
THE PERFECTLY IMPERFECT WAYS WE REMEMBER
Ciara Greene, Associate professor of psychology, University College Dublin
Gillian Murphy, Applied psychology lecturer, University College Cork

13:25 - 14:15
HOW CAN GIRLS AND WOMEN 'HACK' THEIR HORMONES?
Dr Zoe Williams, GP, NHS and media medic

14:35 - 15:25
IS OUR FIXATION WITH DIAGNOSIS MAKING US FEEL WORSE?
Suzanne O'Sullivan, Consultant neurologist, University College London
Claudia Canavan, Head of features, *New Scientist*

15:45 - 16:35
IN CONVERSATION WITH: ADAM KAY, FORMER DOCTOR, AUTHOR AND TV WRITER
Claudia Canavan, Head of features, *New Scientist*

OUR PLANET STAGE

10:45 - 11:35
POWERING A PLANET
Helen Czerski, Physicist, oceanographer and presenter

11:55 - 12:45
KING TYRANT: A NATURAL HISTORY OF TYRANNOSAURUS REX
Mark Witton, Palaeontologist

13:25 - 14:15
IN CONVERSATION WITH CHRIS PACKHAM – MY LIFE IN SIX SPECIES
Rowan Hooper, Podcast editor, *New Scientist*

14:35 - 15:25
BRINK OF EXTINCTION: A JOURNEY THROUGH AN ATLAS OF ENDANGERED SPECIES
Megan McCubbin, Zoologist, naturalist and TV presenter, BBC

15:45 - 16:35
CAN GEOLOGY SAVE THE WORLD?
Chris Jackson, Geologist and professor of basin analysis, Imperial College London

UNIVERSE STAGE

10:45 - 11:35
TALK TO BE ANNOUNCED

11:55 - 12:45
QUANTUM COMPUTING: FROM TESTING THE MULTIVERSE TO A TECH REVOLUTION
Maria Violaris, Quantum physicist, University of Oxford and content creator, Oxford Quantum Circuits

13:25 - 14:15
QUANTUM PHYSICS OF THE EVERYDAY
Mithuna Yoganathan, Physicist and YouTuber, Looking Glass Universe

14:35 - 15:25
SPACE - SO WHAT?
Anu Ojha, Director of championing space, UK Space Agency

15:45 - 16:35
HOW TO CONTAIN A SUN: THE MATERIALS SCIENCE MAKING FUSION ENERGY POSSIBLE
Amy Gandy, Materials scientist, UK Atomic Energy Authority

ENGAGE STAGE

10:30 - 11:00
WONDERS OF THE ANTIKYTHERA MECHANISM
Jo Marchant and Michael Wright

11:15 - 11:45
SCIENCE OF TIKTOK
Jamie Gallagher

12:00 - 12:30
AUTISM IN WOMEN AND GIRLS: YOUR QUESTIONS ANSWERED
Gina Rippon

12:45 - 13:15
ARE THE KIDS ALRIGHT? MENTAL HEALTH IN YOUNG MEN AND BOYS
Dean Burnett

13:30 - 14:00
GREEN CRIME: INSIDE THE MINDS OF PLANET KILLERS
Julia Shaw

14:15 - 14:45
CLIMATE INJUSTICE
Friederike Otto

15:15 - 15:45
THE ILLUSION OF CHOICE: WHAT MAGICIANS' MIND CONTROL TRICKS REVEAL ABOUT YOUR EVERYDAY DECISIONS
Alice Pailhès

16:00 - 16:40
EXPLORING NEURODIVERSITY
Chris Packham, Megan McCubbin and Gina Rippon

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Editor's pick

Why the brain seems to be like a fighter jet

6 September, p 30

From John Harris, Richmond, North Yorkshire, UK

While reading your article on the potentially unstable brain, I was reminded of a close parallel: controlling the Eurofighter Typhoon, a modern jet fighter. In essence, the plane is aerodynamically unstable and requires computer input to function. However, the gain is that the plane is more manoeuvrable and more agile. The key point is that there is no preferred state that would tend to oppose a change of speed or direction. The same might well be true of the brain: balanced on the edge of criticality, without a preferred state, it can respond rapidly to any challenge.

Other causes of the French revolution

6 September, p 11

From Hillary Shaw, Newport, Shropshire, UK

While volcanic activity and related crop decline may have been a factor, multiple causes led to the French revolution, such as the high-spending habits of the French aristocracy and the cost of France's support for the American revolutionary war of 1775-83. This itself was the culmination of several years of repressive British taxation of American colonists. Perhaps if Britain had been more conciliatory to the Americans, France might have peacefully liberalised, with no revolution.

Public transport: the debate continues

Letters, 6 September

From Martin van Raay, Culemborg, the Netherlands

Regarding whether public transport will solve all our travel woes, there is a solution waiting in the wings, in the form of autonomous taxis. A driverless taxi that you hail through an app solves the disadvantages of public transport and might even be cheaper, once you account for the lack of personnel costs.

From Wai Wong, Melbourne, Australia

I totally disagree with Rosemary Sharples on the issue of public transport woes. I grew up in Hong Kong, where only about 10 per cent of the population own a car. I could certainly choose the route and time when travelling on public transport, except during the wee hours. Hong Kong has an excellent subway train system that doesn't have traffic jams and carries about 5 million passengers daily out of a population of about 7.5 million. After emigrating to Australia, I observe one thing: suburbs with bigger car parks also have more overweight residents. I believe low car ownership is a blessing, and indeed Hong Kong as of this year has the longest life expectancy of any country.

Please sign me up for high-tech specs

13 September, p 15

From Sam Edge, Ringwood, Hampshire, UK

Having been a wearer of varifocal glasses for several years, I was heartened by the Taiwanese research using liquid crystals to dynamically switch between near and far visual modes.

The nice thing with conventional bi/varifocal glasses is that one quickly learns to make the necessary head movements to bring the appropriate part of the lens over the object of interest. To match this, liquid crystal or fluid-filled active optics would have to switch very quickly, smoothly and, most importantly, automatically as one attempts to focus on different objects. This would require an eye-tracking element and a rangefinder, further increasing the cost and weight. But if this could be perfected at a low enough cost, it would be a huge boon to many people.

A history lesson for those who want to ditch infinity

9 August, p 28

From Stuart Henderson, Canberra, Australia

The "ultrafinitists" who seek to abolish the use of infinity in mathematics reminded me of the influential Dutch mathematician L. E. J. Brouwer, renowned for proving Brouwer's fixed-point theorem. He went on to found an approach to mathematics that he called intuitionism, which included a rejection of the concept of actual infinity, though it admitted the idea of potential infinity. Intuitionism has since fallen into obscurity. Could the ultrafinitists be reinventing work of the past?

Welcome new approach to taming cancer

30 August, p 40

From Juliet Bullimore, Westleton, Suffolk, UK

I like the sound of treatments where cancer cells are re-educated, so that they revert to behaving like normal cells. I wonder if it would be worth seeing whether a similar method could be used with malfunctioning connections between nerve cells, in the brains of people with Alzheimer's, to encourage them to be repaired.

From Garry Marley, Stillwater, Oklahoma, US

As your dispatch rightly stated, chemically converting cancer cells to benign ones mimics the process of embryogenic differentiation in which myriad cell divisions, beginning with the fertilised egg, yield populations of newly specialised cells with curtailed growth rates. Those cells form our tissues and organs. This is, in fact, an "epigenetic" process in which external chemical signals in the environment control which genes are expressed or repressed.

Because cancer is actually a heterogeneous family of malignancies, identifying these in vivo epigenetic signals has proved to be a daunting task. Paediatric tumours, however, present the greatest chance of success, since they may well be the earliest consequence of embryos that failed to encounter their epigenetic signals.

Is print or digital best while on the toilet?

13 September, p 10

From Steve Tunnicliff, Long Clawson, Leicestershire, UK

You report research that says smartphone use on the toilet may increase the risk of haemorrhoids by nearly 50 per cent. That leaves me to assume, or at least hope, that crosswords and printed magazines are more benign.

From Dyane Silvester, Arnside, Cumbria, UK

With reference to your article "Smartphone use on the toilet may raise risk of haemorrhoids", I am left wondering whether reading the print version of *New Scientist* on the toilet carries the same risk? Or is it only if I read it via the app on a smartphone? More research is required!

For the record

During the Little Ice Age, temperatures dropped by an average of up to 1.75°C, or 3.15°F (6 September, p 11).

The term *atrox* is a Latin word meaning fierce (6 September, p 14).

Want to get in touch?

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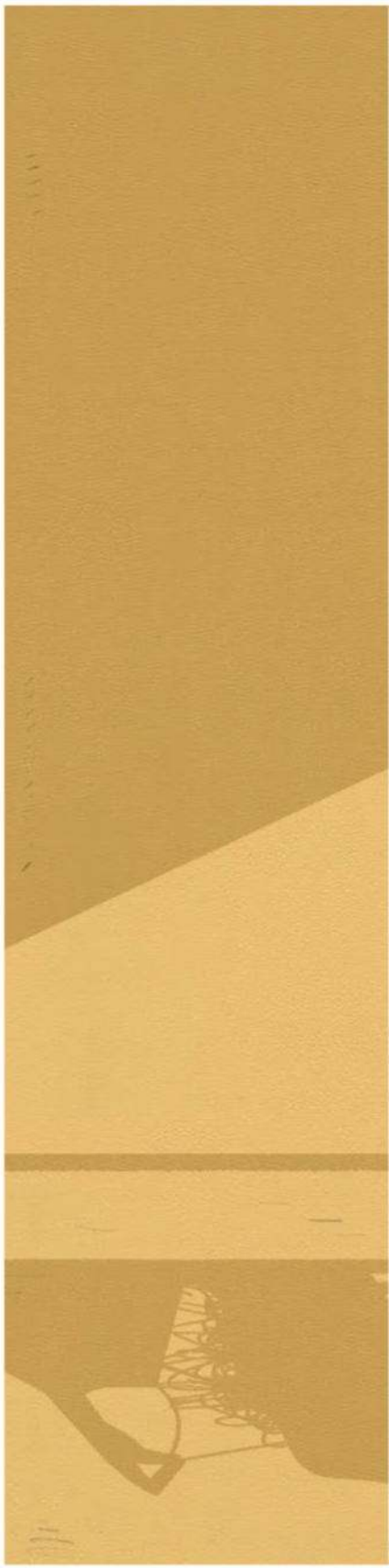
Untangling endometriosis

A link between endometriosis and autoimmune diseases could open up new treatments for this poorly understood condition, reports **Lauren Clark**



PETER YAN

FOR Cherelle Gardiner, the link between her endometriosis and multiple sclerosis (MS) diagnoses, both received in her late 20s, a couple of years apart, has long been clear. "I realised that whenever I was on my period, my legs were also hurting me a lot more," recalls the now-42-year-old, based in south-east London, of the cyclical monthly flaring-up of her two sets of symptoms.

The former is a condition in which uterine-like tissue grows outside of the uterus; the latter is an autoimmune disease affecting the brain and spinal cord. Before either of her conditions was confirmed, Gardiner pushed doctors to investigate the tingling sensations and eyesight issues that led to her MS diagnosis, and later, a scan in which endometriosis was visible. From the time of these early investigations, she remembers wondering if the two conditions were related, before her suspicion calcified into certainty.

Doctors didn't have concrete answers for Gardiner, simply their own theories about a possible connection. A new study, however, has her feeling validated. Researchers have long observed – and women like Gardiner have experienced – that people with endometriosis are at a higher risk of developing chronic conditions. And now scientists from the University of Oxford's Nuffield Department of Women's and Reproductive Health seem to have uncovered why that is. Their research suggests that a shared biological basis underpins endometriosis and autoimmune and autoinflammatory diseases, including MS.

"This study marks a real shift in how we understand endometriosis," says Nilufer Rahmioglu, a postdoctoral research scientist and joint senior author of the study. "It's the beginning of a much clearer picture – like fitting a key piece into a long-missing part of the puzzle – which could help us understand not just endometriosis, but how it fits into a broader network of immune-related diseases."

Putting together the pieces brings us several steps closer to discovering the definitive mechanisms behind endometriosis, and also speeds our way to better treatments – and even a cure.

There is little certainty when it comes to endometriosis. The condition is thought to affect about 1 in 10 women, particularly those of reproductive age. The true incidence rate is likely to be higher, however: endometriosis is chronically underdiagnosed (see "Easier diagnosis", page 38), and people can spend years being told that they just have "painful periods".

The condition derives its name from "endometrium", the tissue that is shed each month during menstruation. "Normally, this lines the uterus like a carpet lines the floor," says Shree Datta, a consultant obstetrician and gynaecologist. "But imagine, then, that you find carpet on the door or the ceiling." When endometrial tissue grows in places it shouldn't, such as on the ovaries, fallopian tubes, bladder and bowel, it can lead to a host of devastating symptoms: infertility, fatigue and – foremost – pain, in the pelvic area, bladder and bowel, and during sex.

The cause is also unclear. "We're still going

on historical theories from the late 19th and early 20th centuries," says Thomas Bainton, a consultant obstetrician and gynaecologist at the Chelsea and Westminster Hospital NHS Foundation Trust. In 1940, American gynaecologist John Sampson posited that the condition was caused by "retrograde menstruation", which sees menstrual blood flow backwards into the pelvic cavity instead of out of the body. This is still a popular theory; however, why and how this relatively common occurrence would then cause endometrial cells to implant in other organs is unclear.

Inflammation has been another investigative focus. In June, a large Swedish study discovered that adverse life experiences from birth to age 15 – such as moving house a lot or having a parent with substance-abuse issues – could increase a woman's likelihood of developing endometriosis, with the study's authors suggesting that higher levels of inflammation in the body could be to blame.

Other mysteries remain. Though women are between four and seven times as likely to be diagnosed if a first-degree relative also has a diagnosis, there isn't a clear pattern that runs in families, suggesting that it could be the product of both genetic and epigenetic contributions. Oestrogen appears to be a driver of the growth of endometrial tissue outside of the uterus – symptoms intensify around times that oestrogen peaks and ease off during menopause – but the exact mechanism is unclear.

Something painfully clear to many is that endometriosis seems to frequently occur alongside other health conditions. Research ›

Easier diagnosis

The path from suspicion to a diagnosis for endometriosis can take an astonishingly long time. Recent studies have found that even though it takes an average of 6.6 years from the onset of symptoms to diagnosis around the world, there is an enormous variation among countries, from an average of eight years in the UK to about three in Brazil.

Researchers put the diagnostic delay down to a lack of popular and professional awareness about the condition, as well as the fact that symptoms can mimic other pain conditions. People living with endometriosis, however, often report feeling that their symptoms have been dismissed. Further complicating the picture, for decades, the "gold standard" for confirming the condition has been investigative laparoscopy. "But it's an invasive test that has its own risks and complications," says Mohamed Mabrouk, a consultant gynaecologist and president of the European Endometriosis League.

Increasingly, however, doctors have more tools at their disposal, including transvaginal ultrasounds or MRIs, to facilitate diagnoses. Andrew Horne at the University of Edinburgh, UK, is also hopeful about work on blood tests that can identify and monitor the progression of the condition.

"Researchers have identified panels of protein biomarkers that are present at different levels in women with endometriosis compared [with] those without," he says. "These could be used to develop a non-invasive test that could potentially replace or reduce the need for surgical diagnosis."

Australian researchers are exploring diagnosing the condition using menstrual blood, while in the US, scientists at Baylor College of Medicine in Houston, Texas, have laid the groundwork for a stool test.

"In menstrual blood, researchers have found certain proteins that are elevated in women with endometriosis, suggesting these could serve as non-invasive biomarkers," says Horne. "Stool tests focus on detecting specific metabolites and changes in gut bacteria that are linked to endometriosis, such as lower levels of beneficial bacteria and certain bacterial metabolites."

Such tests could realistically be expected to be available in the next five to 10 years, he says.

has long shown a link with a host of autoimmune conditions, while a meta-analysis from earlier this year found that endometriosis is associated with a 23 per cent increased risk of cardiovascular diseases and a 13 per cent increased risk of hypertension. Other research has also uncovered a possible raised risk for ovarian and breast cancers.

"But none really went into why," says Rahmioglu. Using data from the UK Biobank, including from more than 8000 women with endometriosis and close to 65,000 women with immune-related conditions, Rahmioglu and her colleagues examined the association between endometriosis and 31 different immune conditions, including MS, coeliac disease, psoriasis and osteoarthritis. They found that women with endometriosis had a 14 per cent higher risk of developing a single immunological condition than women without, but also that this risk compounded – they had a 21 per cent increased risk of having at least two immunological conditions, and a 30 per cent increased risk of having at least three at any point in their lifetimes.

> "This is a real shift in how we understand endometriosis. It's like fitting a key piece into a long-missing part of the puzzle

So far, so in line with previous research. But then came the breakthrough. Using vast amounts of genetic and health data, the researchers scanned the entire genetic blueprint of thousands of people to find tiny differences that might be linked to disease. They then went even further, using another method to see if one condition might actually cause another. In doing so, they found several spots in human DNA that seem to influence both endometriosis and autoimmune conditions such as MS, osteoarthritis and rheumatoid arthritis.

Shared genetics

One of these shared DNA regions, for example, is involved with the expression of a gene that contributes to cell growth, immune response and tissue repair. Another regulates several genes that control how immune cells move through the body during periods of inflammation. One more shared region is known to be active in pain signalling, which Rahmioglu suggests may help explain the shared mechanisms underlying chronic pain experienced across the conditions.

"Large-scale investigations that integrate clinical and genetic data, such as this one, are uniquely positioned to unlock meaningful insights into disease mechanisms," says Andrew Horne, a clinician and researcher at the University of Edinburgh, UK, who wasn't involved in this research. Rather than simply observing a correlation, the study's identification of the underlying shared genetic mechanisms establishes a solid biological foundation for why these conditions tend to co-occur, he says.

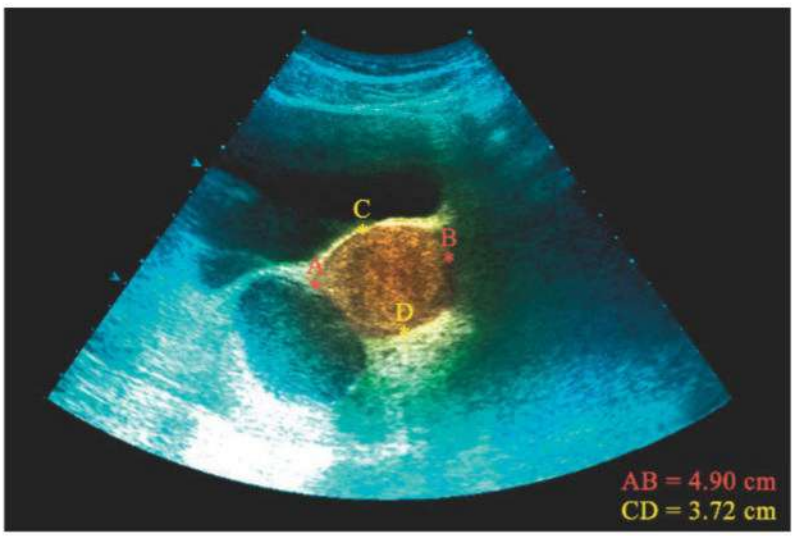
In the short term, this points to possible earlier intervention for both endometriosis and autoimmune conditions. For example, the Oxford team also uncovered a potential causal link specifically between endometriosis and rheumatoid arthritis, meaning that the presence of one could contribute to the development of the other. Knowing that there is a relationship between the conditions means that people who develop one can be more closely monitored for the development of the other, allowing them to start treatment earlier.

"While this isn't part of routine clinical practice yet, the groundwork is already being laid through research like ours," says Rahmioglu.

In the longer term, she says, work is being done to offer even more granularity, in the hopes of potentially identifying sub-groups who may be more likely to develop specific conditions. "We have pinpointed certain genetic variants and genes that need to be further investigated," she says.

But perhaps most significantly to the millions of people living with endometriosis, the findings offer the hope of new treatments. "The identification of this connection is not only exciting – it also opens up promising new avenues for intervention, with the potential to inform the development of therapies that could address multiple conditions simultaneously," says Horne.

Uncovering the overlapping pathways that may drive endometriosis and autoimmune conditions can inform the development of new treatments and the repurposing of existing drugs. "The fact that we now see shared genetic architecture between these diseases opens up the possibility that similar biological processes may be involved in subgroups of women with endometriosis, and we may be able to test treatments already in use without starting from square one," says Rahmioglu. Though clinical trials would still be needed to determine whether drugs already approved for treating autoimmune conditions would be effective for endometriosis, the path is significantly shorter and less costly than developing an entirely new drug. "It can save years," she says.



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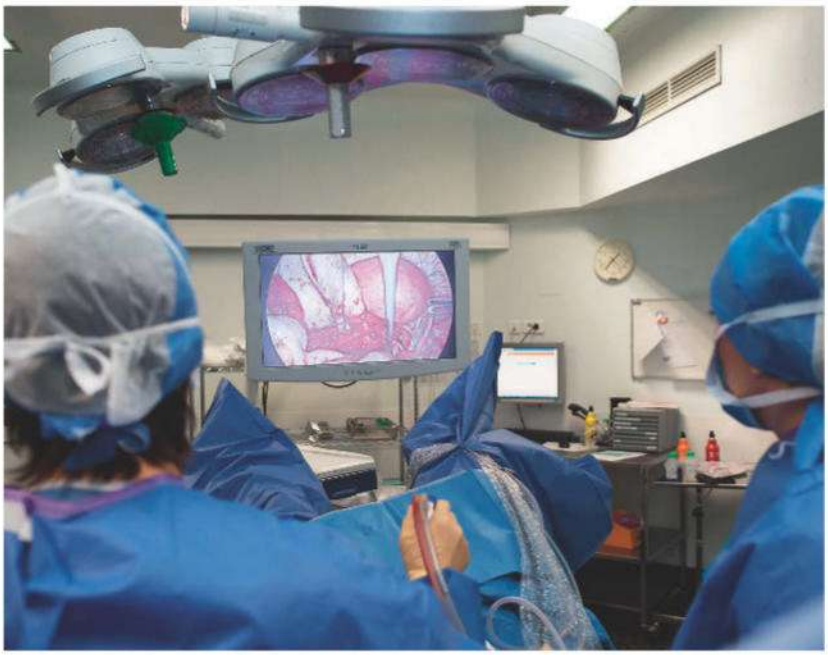
Endometriosis can lead to cysts forming on the ovaries

GAIZKA IROZ/AFP VIA GETTY IMAGES

The Ziwig Lab in France processes saliva tests to help diagnose endometriosis

That a link has become clear only now is something that amazes Gardiner. "I thought that MS and endometriosis had an established relationship already, such was the cyclical pattern of my symptoms," she recalls. "I can remember the exact moment a potential connection dawned on me – I was looking down a hospital corridor, soon after my [endometriosis] diagnosis, and I thought, 'Hang on a minute, are these two related?'" She took her idea to her endometriosis consultant and MS nurse, who shared the same working theory: that because her body was fighting two different things, perhaps one could be "exacerbating" the other. This was more than a decade before Rahmioglu's team would join the dots at a cellular level. "I feel so validated that research is finally shedding light on this, but also frustrated it has taken so long," says Gardiner, who has met many others also experiencing both conditions. "It couldn't have been a coincidence."

That research is revealing a new understanding of endometriosis is cause for hope, something that researchers and people living with endometriosis say is in short supply with existing treatments. "Treatment options at the moment are three-fold," says Joel Naftalin, a consultant gynaecologist at University College London Hospitals: over-the-counter or prescription pain relief; hormonal methods, such as contraceptives, which inhibit endometriosis growth by "shutting down" the reproductive system; or removing the tissue through surgery. ›



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Endometrial tissue can be removed in surgery, but it can return

These are often deployed in combination, but researchers say treatments tend to fall short. Surgery to remove or destroy endometrial tissue is no guarantee that it won't return, while hormonal treatments come with side effects and complications, like diminished fertility and sexual function. For example, in March and May of this year, two new daily pills, Ryeqo and linzagolix, respectively, were approved by the UK's National Institute for Health and Care Excellence (NICE); they work by reducing the production of oestrogen and progesterone to ward off the growth of endometriosis cells. However, the pills come with a trade-off: the new medications tip the body into a "menopause-like" state, says Datta. "For some patients with debilitating symptoms, these can help, but they aren't suitable for those thinking about pregnancy, for example."

Repurposed autoimmune treatments could offer substantive alternatives to existing therapies. Already, some scientists are exploring similar avenues. Bainton is involved in a year-long study in which participants with severe endometriosis are given monthly infusions of an immunotherapy medication designed to dampen the effects of a protein that contributes to the condition. "Treating endometriosis with immunotherapies is a new horizon," he says, estimating that the medication could become available by the 2030s.

Evidence also suggests that targeting inflammation – an immune response implicated in the development of autoimmune conditions – could be a way to home in on endometriosis. Last year, Yale researchers were able to identify and attack the cells associated with inflammation in endometriosis. By knocking out a key protein in those cells, they were able to reduce endometriosis-like lesions in mouse models.

> "Treating endometriosis with immunotherapies is a new horizon

Could drugs used to treat autoimmune conditions help with endometriosis?

MARK THOMAS/SCIENCE PHOTO LIBRARY

Perhaps more significant, however, is what the invigorated scientific interest in endometriosis means. The lack of treatment options for the condition has long been a problem of not only the complexity of the condition itself, but also the lack of research into women's health historically. "But the winds are changing," says Rahmioglu. "Funding bodies are more aware of how common and untackled a condition it is." For those desperate for an end to symptoms that frequently leave them unable to leave the house, like Gardiner, who is currently awaiting surgery for additional gynaecological conditions that she has now developed, such shifts can't come soon enough.

Thankfully, scientists are upbeat about what the next decade of endometriosis care might look like. "We are seeing a shift in hopefully understanding more about this disease, including the multifactorial nature of its immune, genetic and epigenetic mechanisms," says Mohamed Mabrouk, a consultant gynaecologist and president of the European Endometriosis League.

That, says Horne, means a more precision medicine-based approach to treating endometriosis, tailoring care for the individual – and, he says, hopefully a cure.

Like Horne, Rahmioglu stresses that the new research moves the field beyond noticing patterns in people with endometriosis and into showing that one thing is likely to be causing another on a genetic level, something she describes as a "paradigm-shifting step".

"We're not just observing a correlation – we're uncovering shared genetic roots that are providing us with important biological clues and possible targets for future therapies," she says. "That gives us a real chance to accelerate progress in treating endometriosis, which has seen limited innovation for decades. The goal is to use genetic information not just to understand disease risk, but to act on it – so that care can be earlier, faster and more personalised." ▮

Lauren Clark is a freelance journalist specialising in health and wellness

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The Digital Herd: How Arla is bringing cutting-edge innovations to the dairy farm

Forget the pastoral image of a farmer on a stool at dawn. The 21st-century dairy farm is a high-tech hub where cows decide their own milking schedules and data flows as freely as the milk. For Paul Dover, UK Agricultural Director at Arla Foods, at its heart, dairy farming uses "a combination of science, innovation and technology that turns... grass into a nutritious, healthy food that everybody can eat and enjoy".

The most striking innovation is the autonomous milking parlour, where cows voluntarily enter robotic stalls when they feel the need to be milked. Neck collars monitor vital health metrics, while the machine cleans the udders, attaches the milking cups and completes the process without human intervention. This not only supports animal welfare but liberates farmers from intensive manual labour, allowing them to become system managers and data analysts.

This robotic revolution is powered by a torrent of information. Through its FarmAhead™ Check programme, dairy cooperative Arla has spent six years collecting sustainability data, turning its members into farmers of data as well as livestock. This information is used to financially incentivise greener practices, targeting five key areas, from feed efficiency to fertiliser use, to achieve a 30% reduction in on-farm emissions by 2030.

The innovation doesn't stop there. Farmers are now deploying bio-acoustic sensors that monitor biodiversity by analysing birdsong, providing a real-time indicator of ecosystem health. With farms also evolving into renewable energy hubs through solar power and anaerobic digestion, the message is clear: the modern dairy is a sophisticated ecosystem, using science to create nutritious food while pioneering a more sustainable, circular future.

You can find out more by visiting the Future of Food and Agriculture stand at New Scientist Live 2025. For more details go to: live.newscientist.com

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Beyond light speed

Bizarre optical illusions could help us solve a raft of cosmic mysteries, discovers **Jonathan O'Callaghan**

"Shadows can, and do, go faster than light around us all the time"

HERE is a thought experiment for you: imagine shining a powerful laser at the moon, the beam cutting through space until it lands on its dusty grey surface. Now flick the laser so the spot of light sweeps from one side of the moon to the other. It would seem to streak across in an instant – traversing thousands of kilometres in a split second, even faster than the speed of light in a vacuum. How is that possible?

There is no laser pointer powerful enough to pull off this trick. And even if there were, don't panic: nothing would be breaking the cast-iron law of physics that rules out anything moving faster than light. It is only an optical illusion. That said, there are real phenomena out there in the cosmos that create similar illusions. "Nothing with mass can accelerate from below the speed of light to above," says astrophysicist Robert Nemiroff at Michigan Technological University. "But shadows and laser spots and illumination fronts can, and do, go faster than light around us all the time."

Astronomers have long spotted these superluminal illusions, once dismissed as curiosities. But we are now realising some can reveal hidden, surprising details about the universe that no other observation can. Nemiroff even suggests a new type of illusion, light echoes appearing to travel backward in time, that could expose the inner workings of some of the most mysterious phenomena in our cosmos. And with the opening of the Vera C. Rubin Observatory, we might be on the cusp of seeing these fleeting illusions more often.

For decades, astronomers have observed numerous examples of superluminal motion. The first came in 1901, when Thomas Anderson, an amateur astronomer and clergyman in Edinburgh, UK, noticed a new point of light in the Perseus constellation that outshone most other stars. Astronomers rushed to observe it, including those at the Greenwich Observatory in London, and were surprised by what they saw – an explosion whose glowing outer layers appeared to be expanding up to five times faster than the speed of light.

The event, later named Nova Persei 1901, was caused by a thermonuclear explosion called a nova on the surface of a dead star, a white dwarf. At first, its apparent superluminal behaviour baffled astronomers, but in 1939, French astronomer Paul Couderc explained that it was a light echo.

As the explosion's light radiated outwards, it struck clouds of dust at various angles. Some regions lit up faster than others, not because the light was travelling faster, but because of their orientation relative to Earth and the nova. The result was an illusion: bright arcs of light that seemed to outrun the very light that caused them.

That isn't the only illusion to have been discovered. Apparent superluminal motion is used to study powerful cosmic jets, streams of charged particles fired from active black holes, merging neutron stars and other exotic systems. These jets often travel close to the speed of light, and when they light up the surrounding dust, they can produce faster-than-light effects that depend on how we perceive them as they are pointed towards us.

It is something that a child making animals with their hands in front of a torch (or flashlight) might understand. Move your hand slightly closer to the light, and the shadows leap across the wall. The same principle applies in space, where distant sources of light and dust clouds act as the lamp and the screen, respectively.

Just last year, the superluminal jet of a galaxy called Centaurus A, about 12 million light years from Earth, was used to reveal its hidden structure. Astrophysicist David Bogensberger at the University of Michigan tracked a bright knot in the jet that behaved oddly. In radio waves, it appeared to move at 80 per cent of the speed of light, but in X-rays, the same feature seemed to race ahead, at 2.7 times the speed of light.

"This tells us that the radio and the X-ray data show something completely different, which is quite a recent discovery," says Bogensberger. "There's growing consensus that you really see two different populations of plasma within the jets that move differently and have different properties." That distinction, he says, could help refine our understanding of how jets form, what they are made of and how they evolve as they tear through space.

You can also use superluminal motion to work out at what angle these narrow beams hit Earth, says astrophysicist Matt Nicholl at Queen's University Belfast, UK, something not really possible by other methods. "If you measure the energy of a jet that's coming right at you compared [with] a jet that's going a slight angle away, you might get a very different answer," says Nicholl.

That can give astronomers crucial information about how much energy is in the jet. "That tells you how stable neutron stars are and what the pressure is in the centre," says Nicholl. "That's fundamental nuclear physics that we can't measure on Earth."

But, as you might expect, catching these fast-moving signals is difficult. According to Bogensberger, astronomers observe objects that appear to move around 10 times the speed of light, but in rare cases, they can appear to reach 50 times light speed. Most telescopes seldom revisit the same patch of sky, making it easy to miss fleeting effects like these. But with the rise of high-cadence astronomy, scanning the sky repeatedly and in real time, that is beginning to change. ›

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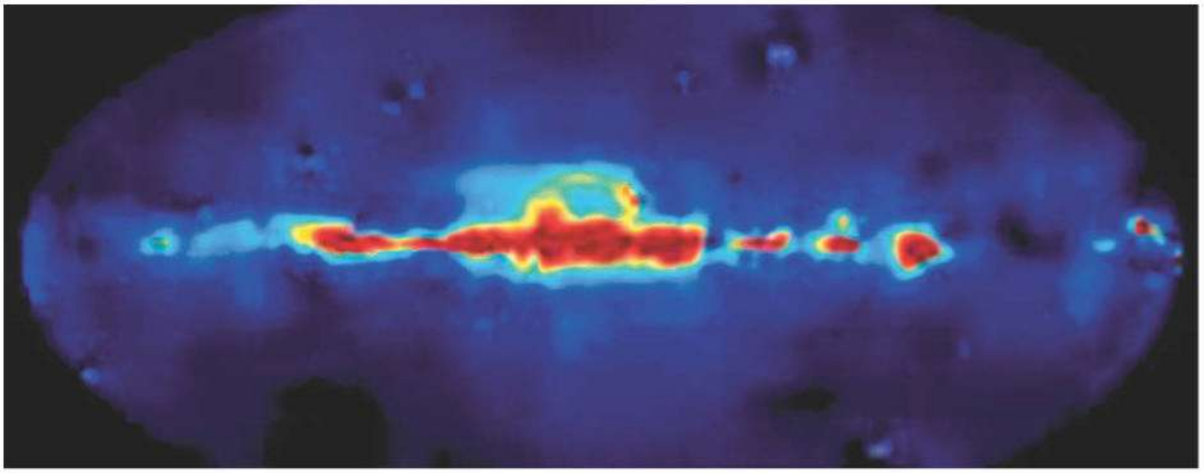

ESA

Left: Gamma rays can be used to map the Milky Way
Right: If a laser was swept across the moon, it would appear to travel faster than the speed of light

Scientists like Nemiroff and Jon Hakkila at the University of Alabama in Huntsville are hoping that this new data will strengthen a theory they proposed back in 2019 to explain one of the most puzzling phenomena in astrophysics: gamma-ray bursts (GRBs). These are sudden, brilliant flashes of high-energy light, thought to come from violent star deaths or merging neutron stars. But details of how they form and why they behave the way they do remain stubbornly unclear.

One enduring puzzle lies in their light curves: graphs that track a burst's brightness over time. Instead of rising and falling smoothly as the burst explodes then fades, GRB light curves often show a ripple-like structure with at least three distinct peaks occurring during the rise, crest and fall of the main pulse. Some pulses contain dozens of such peaks. Stranger still, the first and last peaks often appear to mirror each other, as if the burst were unfolding and then rewinding. "GRB light curves didn't make any sense," says Hakkila.

Physicists had offered explanations ranging from GRBs reflecting off cosmic barriers to complex interactions with clumpy mixes of plasma, radiation and magnetic fields. But these theories often felt contrived, and none explained why the strange echo-like structure was so common.

Hakkila found inspiration in Nemiroff's earlier work. This had shown that, under certain conditions, a wave or particle that appeared to move faster than light through a medium – though still slower than light in a vacuum – could trigger an effect he called "relativistic image doubling". To an observer, it could look like two versions of the same event: one unfolding normally, the other in reverse.

Hakkila took this concept and ran with it. In his new model, a wave or "impactor" within a GRB jet accelerates from subluminal to superluminal speeds. During this transition, the wave passes through the plasma and triggers a burst of radiation. Because it briefly moves faster than light can travel in that medium, the light it emits arrives at the observer in a strange order: first as a normal signal, and then again, playing in reverse. The result, thanks to relativistic image doubling, is a light curve that appears to echo itself: flaring, fading and then flaring again.

"It's like somebody walks into a room, turns on all the lights, and then when they walk out of the room they remember to turn them all off in exactly the reverse order," says Hakkila. He found this effect might explain at least 85 per cent of GRBs in a paper published in 2021. In 2023, researchers Dong-Jie Liu and Yuan-Chuan Zou at Huazhong University of Science and Technology in Wuhan, China, repeated the same analysis with newer data. Not only did their findings support the idea, but their paper revealed these mirrored signals could tell us how fast shock waves travel through the plasma, or whether they are interacting with dense clumps along the way. Far from being observational noise, Liu and Zou argue that these ripples could be subtle signatures of how GRBs are built and how they explode.

Nemiroff, for his part, thinks the idea can stretch even further. Beyond GRBs, he suspects relativistic image doubling events might occur across the universe, too.

One possible candidate is rapidly spinning neutron stars, called pulsars. These often have blazing hot spots on their surface – regions linked to their magnetic poles. If such a pulsar was surrounded by a disc of dust, then one of these spots could scatter off the disc as it rotates towards us. With certain conditions, the scattered beam could appear to arrive before the light from the spot itself, creating the illusion of two identical spots moving in opposite directions.

"What you see is a pair of spots moving away from each other," says Nemiroff. "You

"Apparent superluminal motion is used to study exotic systems like cosmic jets"

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Mysteries of the universe
Hear Harry Cliff describe some of the riddles of the cosmos on 18 October newscientist.com/nslmag

GPKPHOTOS/ALAMY

see one essentially moving in normal time, and one in reverse time."

Now, as data from the Vera C. Rubin Observatory starts to accumulate as it scans the entire southern sky every three or four nights, he thinks there is a chance of actually spotting his superluminal image pairs. "[Rubin] is a very good instrument to see things like this," he says.

Cosmic speed limits

Nemiroff may have to wait. Rubin's data is unlikely to be used immediately for esoteric physics searches like this, says Tessa Baker, a cosmologist at the University of Portsmouth, UK, because its early efforts will focus on more mainstream science such as finding galaxies, asteroids and supernovae. But Rubin, alongside detectors like LIGO, could be used to find another superluminal phenomenon: gravitational waves that move faster than light, she says.

That would be a radical discovery. Astronomers have observed that gravitational waves and light share the same speed limit, as predicted by Einstein's theory of relativity. However, in some models proposed to explain dark energy, the universe may contain additional fields that alter how gravitational waves and light propagate. Light would remain tied to the speed limit we apply to it currently, but gravitational waves could interact with these fields and travel faster.

That would mean the ripples in space-time from a gravitational wave event might reach us before the photons, as picked up by Rubin, says Baker, and it might lend support to alternative theories of gravity.

If and when we do start seeing superluminal illusions more routinely, scientists want to be prepared to wring the most research value out of them. To that end, some are starting to experiment with these effects in the lab. Theoretical physicist Simon Horsley at the University of Exeter, UK, and his colleagues have tested materials such as indium tin oxide that have tunable properties, sweeping lasers across them in a setup that mimics the moon laser pointer experiment. In theory, no information should travel faster than light across the material's surface. But is that really the case?

What Horsley and his team found is that the refractive index – a measure of how much the material bends light – appears to shift in step with the laser's movement, and at speeds that seem to exceed the speed of light. "You have a patch that whizzes across the material," he says. The result is a reflection that seems to come from something moving faster than light – not a real object, but an optical effect.

This hinges on the Doppler shift, the same principle that makes an ambulance siren drop in pitch as it passes. "You can extend it all the way to things moving faster than light," says Horsley, resulting in the angle of the reflected light visibly flipping as it crossed the light-speed threshold.

This matters because Doppler shifts are one of astronomy's main tools for inferring motion – used to measure how fast galaxies recede, how jets are angled or how stars orbit one another. If superluminal illusions can distort those shifts in predictable ways, lab experiments like Horsley's could help us interpret what we see in the sky more accurately – effectively calibrating our expectations against known optical effects.

The material that Horsley works with could also be used to test other superluminal effects that have yet to be discovered. "We've been trying to think if there's any exotic physics we can explore with this," he says, "because we're not really moving anything faster than light, but it does behave like an object that's moving faster than light." Other experiments have probed the effects of superluminal motion too. Earlier this year, Dominik Hornof, a physicist at Vienna University of Technology in Austria, and his colleagues used laser pulses to simulate an object moving close to the speed of light. They found that as the object moved across our field of view, it appeared to rotate, with light from the front arriving sooner than light from the back.

Hornof's team also showed that if the object were turned slightly to travel towards or away from us, like how a jet from a black hole or neutron star merger can sometimes be orientated, it wouldn't just rotate – it would suddenly appear to be breaking the light-speed limit. "If we changed the line of sight to 2.5 degrees, we would receive a superluminal motion of 22 [times the speed of light]," says Hornof. "This would be crazy."

These Earth-based simulations could provide a testbed for the physics behind superluminal illusions, informing how astronomers pick apart signals they may soon receive from the Rubin data.

And there might yet be many more illusions awaiting discovery, including Nemiroff's double images, if they occur as expected. "It's so conceptually cool," says Nemiroff. "There are so many little surprises we keep running into." He predicts it might be similar to how gravitational lensing, the concept of light being bent and warped by massive objects, started as a niche idea before it was observationally seen in abundance.

"Now there are hundreds of lensing events that are being studied," he says. Perhaps the same might be true of superluminal events like double image phenomena or the simpler example of a jet sweeping across a cloud of cosmic dust, like a laser pointer skimming across the moon. ▮

The Vera C. Rubin Observatory may spot superluminal signals

Jonathan O'Callaghan is a freelance science journalist who specialises in astronomy, astrophysics and space exploration

PÄTÉ

The truth about narcissists

The discovery that there seem to be two types of narcissism could help people spot the narcissists in their lives, finds **David Robson**

LOOKING back, the signs were obvious: an extreme need for control, a pathological tendency to exaggerate and an almost comical sense of superiority.

My family member claimed to know more than everyone about everything, no matter the topic. He claimed to have the makings of a world-class teacher, doctor, writer or athlete, while also boasting about his modesty. Any disagreement would result in shouty rants or violent outbursts.

Family friends could barely believe it when I told them. "When he meets us, he acts like charm personified," is how one put it. These were all classic traits of narcissistic personality disorder (NPD), a condition characterised by a disregard for the feelings of others combined with an extreme sense of self-importance, often manifesting in interpersonal abuse. At the time, however, I had no way to make sense of this family member's behaviour – this was before the conversation around narcissism had reached its current level of social saturation.

"We really didn't have the language in the mainstream – it wasn't on the radar like it is now," says Sarah Davies, a clinical psychologist and author of *Raised by Narcissists* and *How to Leave a Narcissist... For Good*. "I remember Googling the search term 'narcissistic abuse' and coming up with just seven results."

The profusion of interest in NPD has raised awareness and given people who have experienced narcissistic abuse a vocabulary to talk about it. But it has also been accompanied by the spread of misinformation, which may prevent those with the condition and the people they hurt from getting the support they need.

So, what is NPD? And can it be treated?

Humanity's interest in excessive self-admiration has been evident since the Roman poet Ovid popularised the mythological Narcissus, who was cursed by the gods to fall in love with his own reflection. In the late 19th century, the term "narcissistic" was initially applied to cases of excessive masturbation. By the mid-1920s, the term came to describe a more general personality disorder, but it would take another 50 years for the *Diagnostic and Statistical Manual of Mental Disorders* (DSM) to include NPD.

NPD, according to its DSM definition, is characterised by grandiosity, a desperate need for admiration and a lack of empathy for others. People with the condition frequently overestimate their abilities and inflate their accomplishments. The bloated ego comes with a sense of entitlement, a need for praise and constant attention, and a feeling of alienation – in the narcissist's view, it would be impossible for other mortals to recognise the problems that come with being so extraordinary. Narcissists are also often preoccupied with envy, either being very envious of other people or convinced that other people are envious of them. Finally – and perhaps most damagingly – many of them manipulate and exploit others, with little regard for the hurt they cause. The consequences can be emotional and physical abuse.

"Not every narcissist is abusive," says Davies, while also noting that recognising narcissistic abuse can be challenging – narcissists may be very skilled in manipulation and gaslighting. Narcissism is also considered one side of the "dark triad", a trio of personality traits that can drive callous and cruel behaviour. Psychopathy, characterised by impulsivity and a lack of empathy, and Machiavellianism, marked by manipulative and sometimes amoral attitudes, make up the other sides.

Psychologists often use a self-reported questionnaire called the Narcissistic Personality Inventory (NPI) to measure narcissistic traits in the general population. A formal diagnosis of NPD typically involves an in-depth conversation with a health practitioner. However, someone with a problematic sense of superiority may reject the very idea that they need treatment, making them unlikely to seek help for a problem they don't believe they have. "A true narcissist will believe that any issues are somebody else's fault," says Davies.

This can make it hard to estimate the total number of people living with NPD, and studies of the general population have provided mixed results. The National Epidemiologic Survey on Alcohol and Related Conditions offers the largest sample. Between 2001 and 2002, researchers conducted face-to-face interviews with 34,653 US residents. They identified 2148 people with NPD, giving an estimated prevalence of 6.2 per cent. Other, smaller surveys have tended to find lower rates, meanwhile, with an average prevalence of 1 per cent across the various studies.

"Narcissists have a desperate need for admiration and a lack of empathy"

The precise figure may be a moot point, however, since most psychologists would agree that NPD represents the extreme end of a behavioural spectrum that exists in everyone. "To some extent and in certain contexts, these traits can even be adaptive," says Emmi Koskinen at the University of Helsinki in Finland. In moderation, a belief in oneself can motivate us to achieve great things, and there is nothing wrong with being assertive about our needs and wants. "However, when [these traits] become more pronounced, they tend to lead to interpersonal difficulties and negative consequences for both the individual and those around them," says Koskinen.

Identifying narcissism can help ›

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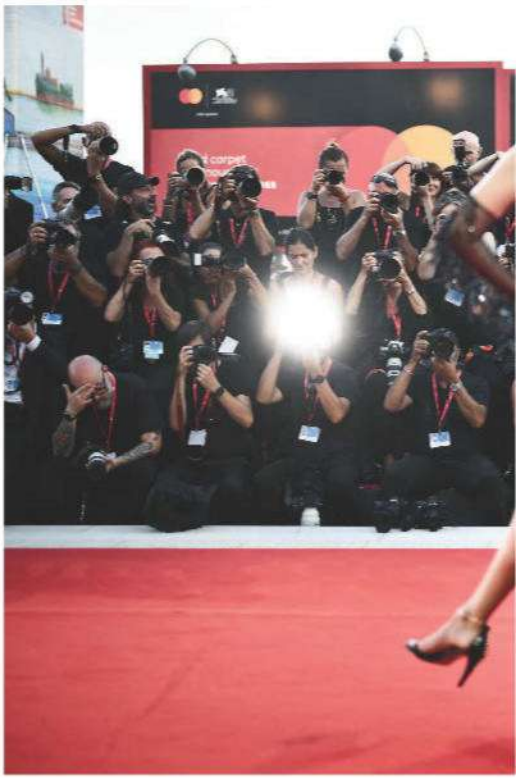

MARCO BERTORELLO/AFP VIA GETTY IMAGES

psychologists understand how narcissists process the world around them – and possibly help them change.

Though the definition of NPD in the DSM cites a lack of empathy as intrinsic to the condition, researchers point out that the relationship between empathy and narcissism is complex. For example, one 2023 analysis of several studies found that while affective empathy – feeling what others are feeling – was impaired in people with NPD, cognitive empathy, or knowing what others are feeling, was not. The implication is that people with narcissism might be aware of others' feelings – they just might use that information for their own self-serving ends, or they don't care.

Bruised egos

This lack of concern for other people's emotions is in stark contrast to their preoccupation with their own feelings. Narcissists are often easily offended. In 2015, for instance, Christopher Cascio at the University of Wisconsin and his colleagues asked people to play a computer game in which three players pass a ball to each other. Unbeknownst to the participants, the other two players were controlled by the computer – and they slowly began to ignore the human. In most people, the resulting feelings of social exclusion led to heightened activity in areas of the brain known to process distress, including the anterior insula, and the extent of that activity seemed to correlate with their scores on the NPI. The more narcissistic they were, the more distress they felt.

Such findings have led researchers to speculate that narcissism arises from a heightened concern about social evaluation, with the self-aggrandising behaviour serving as a defence against a bruised ego.

Along these lines, Koskinen and her colleagues recently asked participants to take the NPI before splitting them into pairs to talk about life's highs and lows, such as times they felt admired or ashamed. Meanwhile, electrodes on their fingers measured how much they were sweating, an indication of how much stress they felt. The higher a person scored on the NPI self-evaluation, the more they perspired during the more intimate parts of the conversation. They cared so much about impressing the other person that it was seriously stressing them out.

This heightened attention to others' reactions was evident in a series of studies, also published earlier this year, that examined narcissists' perceptions of ostracism. In one experiment, Christiane Büttner at the University of Basel, Switzerland, asked online volunteers to consider a series of fictitious scenarios exploring perceptions of social exclusion. People scoring higher on a questionnaire measuring narcissism were significantly more likely to read situations as intentionally exclusionary, compared with participants with lower levels of the trait.

"Any perceived threat to their status or recognition is deeply aversive," says Büttner. This bias was evident in people's reflections on their lives when participants were asked to keep track of their social interactions each day for two weeks. The more-narcissistic participants reported experiencing greater social ostracism in their daily exchanges – when asked to recall how many times they had been excluded over the past 14 days, they overestimated the number of incidents they had recorded. This suggests that their memory is biased towards feelings of exclusion.

You might think that being excluded would decrease someone's delusions of grandeur, yet a further study suggested that the opposite is true. Analysing data from a 14-year study, Büttner found that people's sense of being ostracised could predict a rise in their narcissistic traits over the following 12 months. She speculates that feeling socially excluded "triggers self-enhancing defences" to protect them from the pain.

The problem is that, thanks to their antisocial behaviours, people who already display narcissistic traits to begin with are also more likely to be ostracised. The result may be a self-perpetuating cycle. "If exclusion is repeated or chronic, individuals might begin to compensate by inflating their self-image, becoming more self-focused, or engaging in more attention-seeking or antagonistic behaviours," says Büttner.

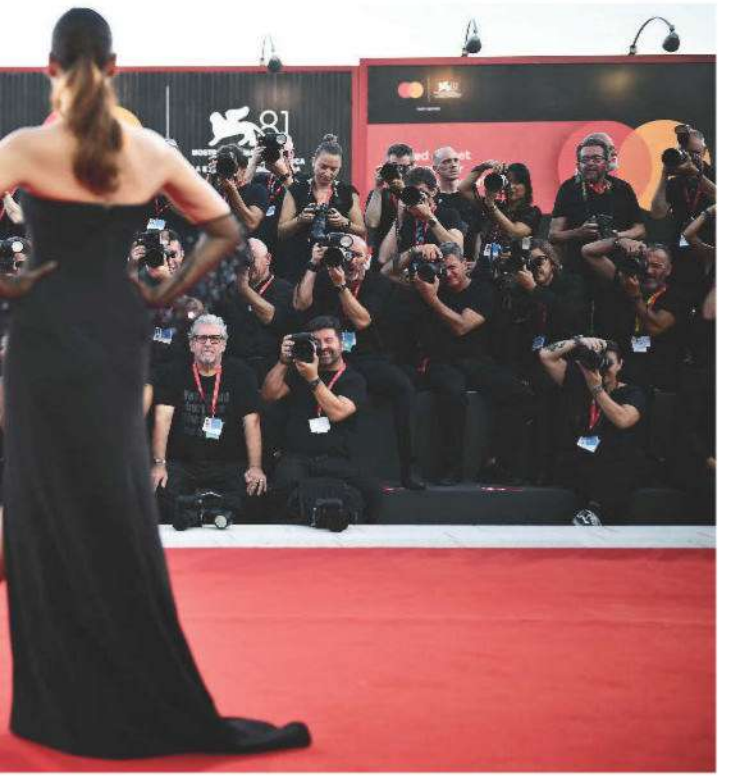
STEVE GALE/UNSPLASH

Is selfie-culture causing a rise in narcissism?

While the DSM doesn't differentiate between different flavours of narcissism, many psychologists argue that it can be separated into at least two subtypes, depending on the way it manifests. Grandiose, or overt, narcissists seem more outwardly confident and are more likely to boast and brag. Vulnerable, or covert, narcissists appear more introverted. They secretly see themselves as special, but they are less likely to show off and may instead seek reassurance from others.

"Vulnerable narcissists are more softly spoken, more shy, more brittle, appear to have lower self-esteem, so that you would never initially consider this person as being very narcissistic," says Ava Green, a forensic psychologist at City St George's, University of London. "But once you get to know them, you see beneath that facade of vulnerability there are these underlying traits: expectations of entitlement to special treatment, [self-enhancing] fantasies about themselves, and the exploitation of other people."

Similarly, a grandiose narcissist may seem more outwardly confident, says Green, "but they are constantly yearning for other people's attention to boost or regulate their



The term "narcissism" is incorrectly used to describe all sorts of behaviour

"Some have claimed that social media may be driving up the incidence of narcissism"

own self-esteem, so there's always an underlying vulnerability". At their core, she says, they are the same – vulnerable narcissists may have escaped our attention in the past, she says, but "we shouldn't underestimate the amount of harm they can do other people".

Gender gap

"The type of abuse doesn't differ between the grandiose and vulnerable subtypes, it just depends on individual circumstances," says Green. The DSM assessment places far more emphasis on the type of behaviour seen with grandiose narcissism than with vulnerable narcissism. This might be a bigger blind spot than it first seems: grandiose expressions of the behaviour are more commonly seen in men, whereas women might be more likely to exhibit vulnerable features. This may explain why up to 75 per cent of people diagnosed with NPD are men. Green and her colleagues found that this apparent gender gap shrinks when you consider the subtypes – women score more highly than men on vulnerable narcissism.

"It isn't the fact that narcissism is a gender-specific trait," says Green. "Women exhibit these features too, but in a way that's not captured by the grandiose assessments." She points out that the different subtypes often align with cultural gender norms for men and women. It may seem more socially acceptable for a man to ebulliently boast about his skills and abilities, for instance, whereas a woman is expected to act more passively in public.

Much of the recent conversation around narcissism has taken place online – fitting, because narcissism is now often most visible on social media platforms. Large studies have shown that narcissism scores can predict how often people share material with others, although it is still unclear whether this is limited to grandiose types.

Some experts have even claimed that social media may be driving up the incidence of narcissism, though the evidence supporting this is scant. "I'm not saying it's impossible, but I don't think we have a lot of good data yet," says René Mõttus, who researches personality at the University of Edinburgh, UK.

Social media may not be changing the prevalence of NPD, but it has certainly helped to raise awareness of the condition and the damage that it can wreak on our relationships. Therapist Ramani Durvasula, for instance, hosts the popular *Navigating Narcissism* podcast; she has more than three-quarters of a million followers on Instagram. Lee Hammock, meanwhile, is a recovering narcissist with more than half a million Instagram followers who has undergone years of therapy to overcome his solipsistic tendencies. At the time of writing, more than 1 million Instagram posts have been tagged with #narcissism.

The quality of the online discourse can be mixed. "Increased awareness and discussion is really helpful, but the information is not always clinically reliable," says Davies. The term narcissism is now being used to describe any emotionally immature behaviour, she says, which may lead people to misdiagnose the underlying problems they are facing. "We've got to be a bit more careful about these sweeping generalisations."

Davies is particularly worried about the number of unqualified influencers dishing out advice. "All sorts of people are sharing their experiences and, worryingly, offering services to help others heal from narcissistic abuse, even though they have not been trained to do so," she says. "It's quite ironic, because that is actually quite a narcissistic thing to do."

If you are or have been the victim of narcissistic abuse, Davies recommends looking for authoritative sources, such as the UK charity See Through NPD, and seeking support from trained professionals. "Therapy can really help you to make sense of what you've been through," she says. (If you are in the US, the National Domestic Violence Hotline can help.)

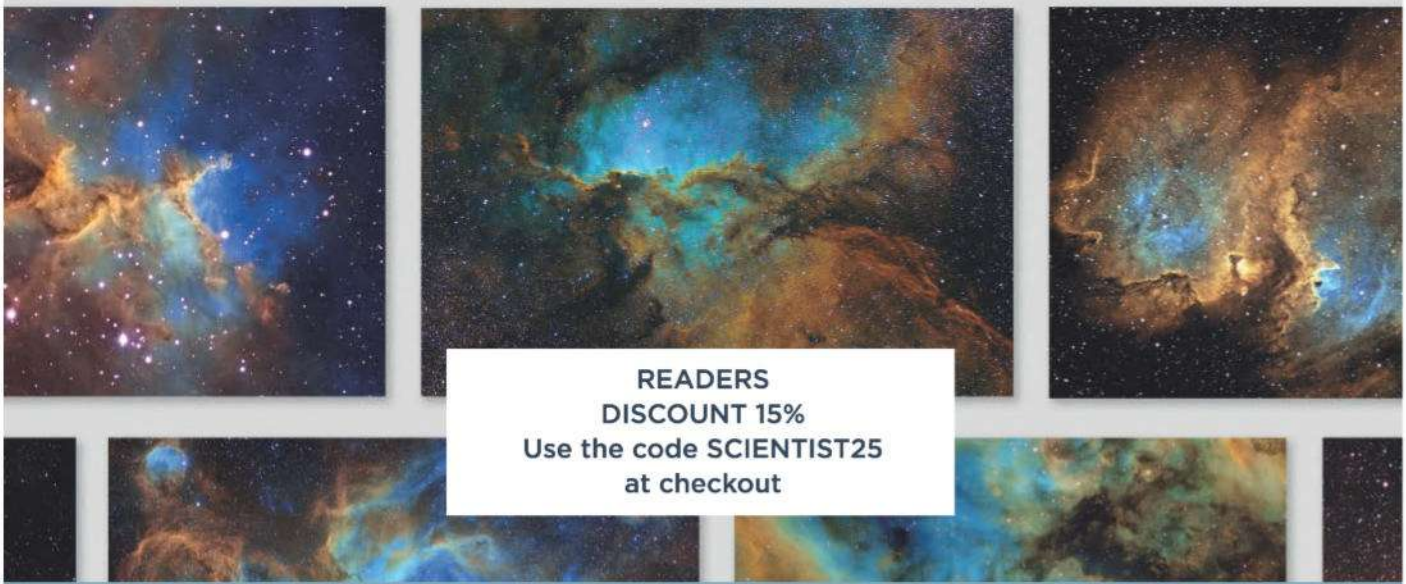
Though narcissists have a reputation for being very difficult to treat or change, some case studies suggest that they can respond to talking therapy. In 2024, for instance, a team led by Igor Weinberg at Harvard Medical School published a paper on eight people who underwent treatments such as psychodynamic therapy, which helps people to explore the effects of early childhood experiences, or dialectical behaviour therapy, which helps people to manage difficult emotions. After up to five years, they no longer met the clinical diagnosis of NPD, and many reported positive life changes, such as gaining employment or getting married.

Some leopards, it seems, can change their spots – but it remains to be seen how common this is. The individual needs to acknowledge their faults, after all, which won't come easily to someone who doesn't believe they have any. As I found after decades of interactions with my family member, there is often no reasoning with a narcissist. In their eyes, they can do no wrong, and we are simply better off without them in our lives. ▮

David Robson is the author of *The Laws of Connection: 13 social strategies that will transform your life*

GALAXY ON GLASS

SPECTACULAR WALL ART FROM ASTROPHOTOGRAPHER CHRIS BAKER



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Dear David

Do I really belong?

Feeling you don't fit in is agonising, wherever you find yourself in life. **David Robson** shares some helpful science

David Robson is an award-winning science writer and author of *The Laws of Connection: 13 social strategies that will transform your life*

Further reading

Besides describing the psychology of belonging, Gregory Walton's book *Ordinary Magic: The science of how we can achieve big change with small acts* provides practical strategies for overcoming mental obstacles in our personal and professional lives.

Dear David, an evidence-based advice column, appears monthly. Drop David a line with your social dilemmas at davidrobson.me/contact

Next week

Stargazing at home

SEPTEMBER is now upon us, and with it the new academic year. Like many students flying the family nest, one of my readers is anxious about her new life at university. She is the first in her family to attend higher education and is sure she will struggle to fit in.

Over the past 20 years, psychologists have come to recognise the many ways that someone's sense of not belonging can damage their well-being. Fortunately, this research also offers some ways to mitigate those feelings – strategies that may benefit anyone experiencing impostor syndrome, or the fear we don't deserve our success .

One of the first things to remember is that your emotions will fluctuate wildly. Studies show that those who lack a sense of belonging are much more likely to experience impostor syndrome. One day you are sure you have found your niche; the next, you feel adrift due to negative feedback that leaves you questioning your competence.

To capture this, psychologists ask people to rate statements like: "When something bad happens, I feel that maybe I don't belong at this institution." As you might expect, the sense of belonging tends to be more vulnerable to external influences in people from ethnic minorities, girls and women taking STEM subjects and first-generation students – and this has important consequences. People with these concerns can be less motivated and perform worse in exams. The increased stress can also take its toll on physical health, leading to more visits to the doctor.

FATCAMERA/GETTY IMAGES

Gregory Walton at Stanford University in California has pioneered research in this field, testing many strategies to bolster students' sense of belonging. The interventions take the form of stories from past students who have described their anxieties and how they overcame them. Next, the participants write about their concerns and the strategies they use to feel more at home. The benefits can be seen in both the short and long term, enhancing grades and well-being for years.

As Walton explains in his recent book *Ordinary Magic*, we can all use these principles. A good first step is to identify an experience that left you questioning whether you belong in your community. You then explain to a listener why you feel like this, without judgement, before generating an alternative interpretation.

Suppose you feel you have been socially slighted, you may wonder whether it is the result of snobbery about your background. But it is equally possible that the person who slighted you was simply having a bad day, or perhaps they just have a terrible personality. Either way, their views don't reflect those of everyone around you.

As your confidence increases, you can better engage with the community in question – until, hopefully, you wonder why you ever felt out of place. ▮

These articles are posted each week at newscientist.com/maker

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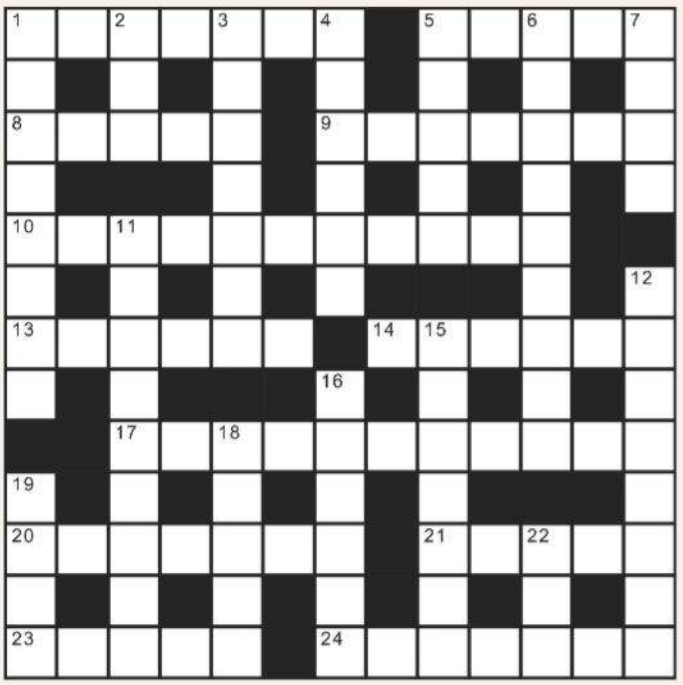
Cryptic crossword #171 *Set by Rasa*



Scribble zone

Answers and the next quick crossword next week

ACROSS

1 Close-mouthed person faces our uproar (7)
5 Oxygen injected into fizzless beverage (5)
8 Carry around piece of rich cake (5)
9 Listen to comparatively brassy rock (7)
10 Excited if CERN gets filled with university lab equipment (11)
13 One in a white coat helps to make better minestrone (6)
14 Wellness lodge's opening disrupts shrubland habitat (6)
17 Choose to rely upon shaking salt, for example (11)
20 Wind cotton fabric very well (7)
21 Dull YouTube upload about unfinished app (5)
23 Wet and muddy lad eating peeled eggs (5)
24 Son and I hurried back for brandy cocktail (7)

DOWN

1 Copper stimulates potassium-depleted finger parts (8)
2 Broadcast duo, first off (3)
3 Nothing stirring in Reno club (3-4)
4 Spurn extremely rude fan (6)
5 Cast loud windbag? (5)
6 I spy an old bust being exhibited (2,7)
7 Root is right in the way (4)
11 No brownish colour in good pagination (9)
12 Skilled guitar player more flushed after first half of show (8)
15 Changed sweetheart turned couple from Venice down (7)
16 Wagers dictator's possibly rare items (6)
18 English post office axes adhesive (5)
19 Taxi under small protective covering (4)
22 Initially, plumber with work experience put back pipe material (3)

Our games are now solvable online
newscientist.com/games

Quick quiz #321
set by Corryn Wetzel

1 What does URL stand for?

2 Which part of the brain is primarily associated with language production?

3 What term describes molecules that are mirror images but can't be superimposed?

4 What is the name of the virus that causes chickenpox?

5 Which mammal has the highest mean blood pressure?

Answers on page 55

BrainTwister
set by Katie Steckles
#92 Squares in piles

If you write down the squares of the numbers 1 to 7, can you organise them into two piles with equal sums?

Can you swap two numbers between the piles so that you can add 8^2 to one pile and still have two piles with equal sums?

Can you swap two numbers in this new solution so that you can add 9^2 to one pile and still have two piles with equal sums?

Answers next week

Duly noted

Does left-handedness or right-handedness make for a better pianist?

John Elliott
Bramhall, Stockport, UK
I am a pianist of unimpressive amateur ability and have always found that published music at my level is much more demanding on my right hand than on my left.

Being right-handed myself, this is OK. It might appear that composers naturally assume that the pianist is right-handed; but there is also the important factor that, for purely acoustical reasons, most of the detail in piano music is in the upper registers. That is probably the reason that the keyboard has evolved to rise in pitch from left to right.

However, I am constantly amazed at the achievements of top-rank pianists who are professionally trained and can do remarkable things with their left hand as easily as with their right. In every case, you will find that the pianist had mastered piano technique at an early age, maybe 10, but certainly below 15. At that age, the brain is plastic and malleable, and can be readily

"Below the age of 15, the brain can be readily trained to override its inherent tendency towards left- or right-handedness"

trained to override its inherent tendency towards left- or right-handedness. Studies have shown that connections between the two sides of the brain are increased, and the motor cortex is enlarged.

The real question I would like to ask is: Are these brilliant pianists also ambidexterous in other activities?

David Kroop
West Friendship, Maryland, US
I started playing the piano at the age of about 8 and have always been a "lefty". My father was left-handed and my mother started that way, but was corrected early on. Both were trained classical musicians. So I have been a pianist for about 70 years and have played in bands off and on during that time.

I like to sit down at the piano and compose tunes every day for about an hour, trying odd combinations of melody lines and notes. My style for the left hand tends to be intricate, typically creating an intertwining sound to support and emphasise the right hand. In piano playing, the right hand typically carries the melody and the left the accompaniment. So being trained that way, it comes naturally.

I would say that when I play for myself, I tend to be more creative, always looking for unusual progressions and note combinations. So my conclusion is that the saying that "lefties" are more creative musically and artistically seems to hold true for playing a piano. That is, playing isn't so much mechanical as it is being creative in the performance part of the music.

In that sense, when it comes to original music I excel at playing it, but when it comes to the performance of established melodies or compositions, the "righties" have it.

Tony Budd
Wickford, Essex, UK
I don't know whether it applies to pianists, but left-handed actors represent a higher proportion of the acting fraternity than the average 10 per cent of left-handers in the general population.

ZEYNEPKAYA/GETTY IMAGES

This week's new questions

Toilet trained **When Mollie, my cockapoo, needs a poo while walking along a busy road, she positions herself dangerously close to the traffic. I have observed this behaviour in other dogs. Why do they do it?** ***Mark Webster****, Rugeley, Staffordshire, UK*

Wrapping up **Should the bubbles on bubble wrap face the inside or outside of the object?** ***Finley Elliott****, via email*

Why do dogs like to sit dangerously close to traffic when pooing by a busy road?

This may be because writing from left to right is more difficult for left-handers, and so any career with little need for writing (like acting or piano playing) is more attractive to left-handers.

But if left-handed pianists were "superior", it might be because in childhood they had to work on making their right hand good enough for writing and other skills. That means they have two skilled hands, rather than the excellent right hand (but less-skilled left hand) of right-handed pianists.

My brother, who is a left-handed orchestral viola player, tends to agree.

Baby talk

Why do we speak to babies and pets in cute, silly voices, as opposed to our normal speaking voice?

Ros Groves
Watford, Hertfordshire, UK
Infant-directed speech (IDS), or "motherese" as it is also known, is the instinctive use of a higher-pitched voice when speaking to small infants and pets. It is far from silly, however, especially when used in communication with babies and small children.

It is characterised by a slower, more deliberate way of speaking, with strongly exaggerated melodic contours, wide contrasts of volume and long, drawn-out syllables that help to mark out the boundaries between individual words as well as drawing particular attention to nouns and verbs; the key words to communication.

Interestingly, medically safe experiments conducted on fetuses in the second and third trimesters of pregnancy have shown that at this stage of development, they begin to react with significantly more interest when exposed to IDS as opposed to the faster, lower and less-exaggerated pitches of adult-directed speech. This is shown through an increased heart

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Tom Gauld
for New Scientist

THE PROGRAM HAS DETECTED A SIGNAL SENT FROM ANOTHER GALAXY, BUT WE NEED TO UPGRADE TO A PAID VERSION BEFORE WE CAN REPLY.
CHOOSE A PLAN TO UNLOCK REPLIES:
STUDENT
BASIC
PRO
EXPERT

rate and more head turns.

Babies are also more sensitive to higher-pitched sounds, finding them comforting and reassuring, which may well reflect the fact that it is the mother's voice that predominates during our earliest developmental stages.

Sight unseen

Is short-sightedness found in other animals? Did it also affect ancient humans? (continued)

Peter Bursztyn
Barrie, Ontario, Canada
I am not sure how one could determine whether a wolf, an eland or a cheetah were short-sighted. I can't imagine devising something like an optometrist's eye chart for animals.

Moreover, if a solitary hunter like a leopard were myopic, its success in locating prey would be compromised and they wouldn't thrive. In the case of social hunters like African wild dogs, a myopic animal might survive by sharing the prey brought down by others.

"Infant-directed speech is characterised by a slower, more deliberate way of speaking, with long, drawn-out syllables"

The problem is serious for solitary prey animals. If such an animal can't see well, a predator is able to approach closely before pouncing. The issue is less acute for prey animals travelling in herds. Members of the group with sharper vision can be relied upon to sound the alarm. This is probably why the great majority of animals, predators and prey, live in groups.

For humans, the issue is more nuanced. I have thought about this off and on for decades, because my right eye is very myopic and requires more than twice the correction that my left eye needs. This condition is clearly hereditary: my brother has the same pattern of myopia, as did our father. It appears confined to the male line because my daughters don't need corrective lenses at all. Myopia would have died out entirely unless it – at the bare minimum – didn't greatly disadvantage humans with the condition.

First of all, humans are rarely solitary. In a hunter-gatherer society, a myopic individual would simply avoid hunting. On the other hand, myopia would have to be severe to impede the gathering of fungi, nuts, fruit or nutritious vegetation.

As societies became more advanced, opportunities would appear for myopic members to specialise in tasks benefiting from acute close vision. Some examples would be stone knapping (making stone tools), grooming (locating lice and other parasites), wood carving and jewellery crafting.

I would suggest that myopia did affect ancient humans. However, they likely found it useful. Had it not been, "survival of the fittest" would have eliminated the trait. ▮

Answers

Quick quiz #321 *Answer*

1 Uniform Resource Locator
2 Broca's area
3 Enantiomers
4 Varicella-zoster virus
5 Masai giraffe

Quick crossword #192 *Answers*

ACROSS 1 Orchid, **5** Classify, **9** Plumbism, **10** Obtuse, **11** Telluric acid, **13** Levi, **14** Enuresis, **17** *War Games*, **18** Ogee, **20** Biochemistry, **23** Bikini, **24** Nineteen, **25** Backbone, **26** Simple

DOWN 2 Roll, **3** Hamstring, **4** Drills, **5** Computer science, **6** *Aconitum*, **7** Site A, **8** Fossilised, **12** Hepatitis A, **15** Ecosystem, **16** Impetigo, **19** Stones, **21** Crick, **22** Teal

#91 Balls in boxes *Solution*

The balls can go in the boxes in 24 ways. You can calculate this by multiplying the number of choices for each box, which decreases by 1 each time ($4 \times 3 \times 2 \times 1 = 24$). This can also be expressed as 4 factorial (4!). Excluding cases where a ball is in its own box, we are left with nine possibilities, which are called derangements. For the balls to follow the pattern in the next part of the question, there are $3 \times 2 \times 1 \times 1 = 6$ arrangements. These three values strictly decrease for numbers of boxes greater than four, as the second set of solutions is included in the first, and the third set (in which each ball will also never be in its own box) is included in the second.

A Swift botany lesson

We never miss a beat, so Feedback, prompted by assistant news editor and Swiftie Alexandra Thompson, has been taking a close look at a major paper in the *Annals of Botany*, published in August. It is called "Dance with plants: Taylor Swift's music videos as advance organizers for meaningful learning in botany".

The thesis is that high school students exhibit "a general low interest in plants", leading to "plant blindness". Teachers struggling to convey the magic of botany are repeating material and are getting sick of it. Plants are considered mid, so students aren't sneaking out to the garden to see them. I just, I mean, this is exhausting, you know? Nobody's really interested in botany, but you should be, you should be, you should be.

However, with autumn leaves falling down like pieces into place, the researchers have a possible solution: showing their students Taylor Swift videos.

Now, this may not seem relevant. Swift isn't the kind of girl who should be barging in on a learning occasion. But her videos do show a lot of plants. "Out of 61 official music videos available on Swift's YouTube channel, 53 (87%) showed botanical elements," the authors note.

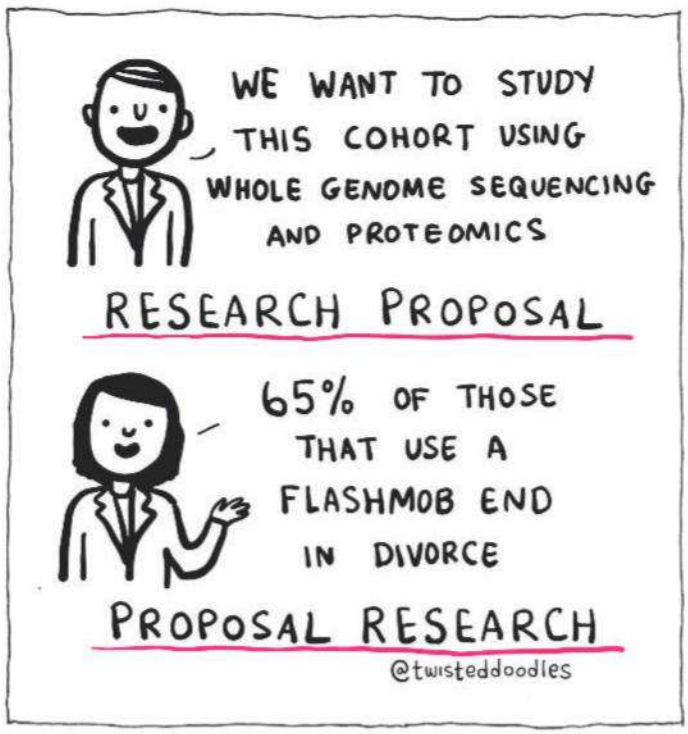
By showing videos like the greenery-drenched one for *Cardigan* in their classes, the authors were able to introduce topics like "the concepts of photosynthesis, competition for lightning, forest litter, nutrition cycling, seasonal variation, canopy structure, plant habits and morphological features".

Even though botany is a rose garden filled with thorns, the students became excited about plants, saying things like, "You look like my next mistake."

Communicators of botany: it is a revolution. What you are looking for has been here the whole time. Stop pretending you aren't secret Swifties and start using her videos as teaching aids. Soon, you will win your students over.

Feedback looks forward to an update once the researchers have had a chance to listen to *The Life of a Showgirl*, which, at the time of writing, is slowly lurching toward your favourite city.

Twisteddoodles *for New Scientist*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AcRONyMs GAlorE

Feedback continues our quest for the most inspired scientific acronyms, or failing that, the most hopelessly forced and unnatural ones. Readers highlighted two, which Feedback really should have spotted – because they were printed in this very magazine.

First, Erik Foxcroft points out that Graham Lawton's feature on chronic sinus infections, printed "a few pages before your column", mentioned the Sino-Nasal Outcome Test, or SNOT. It was right under our nose. The SNOT was mentioned by Feedback in 2001, but we had forgotten about it, so now we're doing it again.

Meanwhile, Johan Gotthardt Olsen highlighted a September *Nature* paper, describing peculiar rock formations discovered by the Perseverance Mars rover, which might be evidence of ancient Martian life. This was covered by *New Scientist* in detail, but we missed acronyms that Olsen spotted.

One of the instruments is called RIMFAX, in honour of Hrímfaxi, the Horse of Night in Norse mythology. The acronym is derived, in a suitable fashion, from "Radar Imager for Mars' subsurFAce eXperiment".

But things improve. "We get our reward further on, where we meet SHERLOC and WATSON," writes Olsen. These stand for "Scanning Habitable Environments with Raman and Luminescence for Organics and Chemicals" and "Wide Angle Topographic Sensor for Operations and eNgineering". Olsen says: "I tip my hat in deep respect of the powerful minds behind those two."

Feedback wants to know why Perseverance didn't also carry the Monitor Of Raman Iridescence And Radiation Tomography Yardstick. Also, Feedback should read *New Scientist* sometimes.

Critters, gremlins, oh my

Exciting news from *The Wall Street Journal*, which reports that OpenAI is making its first film. Well, sort of. OpenAI is "lending its tools and computing resources" to Vertigo Films, which is producing the movie based on an idea by Chad Nelson, a "creative specialist" at OpenAI.

The film will be called *Critterz*, presumably because the correctly spelled title *Critters* was already taken by a science fiction-comedy-horror film from 1986. The startling originality doesn't stop there. It is the story of "forest creatures who go on an adventure after their village is disrupted by a stranger".

The film is an expansion of a 2023 short film, also called *Critterz*, which you can watch for free on YouTube. The short is billed as "the first animated short film utilizing the generative AI power of Dall-E to design ALL the visuals – every character, every background... basically the entire critterz world".

Only Dall-E could have come up with designs as wild as the critterz, which definitely don't look like the monsters from *Where the Wild Things Are*. The producers did hire animators to make the short, but there seems to be little, er, animation. One YouTube commentator noted: "I love watching a whole movie of characters standing in one place looking at me."

Feedback sat through the whole thing, and we can report that the best joke is that the film is narrated by "David Attenborough's neighbour, Dennis". We can't wait to see how exciting this becomes when it is stretched out to feature length. Apparently it debuts at Cannes next year. Mark your calendars.

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